6 FLOOD RISK AND SURFACE WATER DRAINAGE

6.1 Introduction

6.1.1 Overview

This Chapter assesses the potential impacts of the Proposed Development on the water environment, and the likely significance of such effects during the construction and operational phases.

The Chapter addresses the following receptors:

- Surface water (watercourses, reservoirs, lakes, ponds and wetlands);
- Flood risk management; and
- Land drainage

The Chapter describes the methods used to assess the likely significant effects; the baseline conditions that exist at the Site and within the surrounding area; the mitigation measures required to prevent, reduce or offset any significant negative effects; and the likely residual effects after these measures have been adopted. The assessment is based on the project description and site context as set out Chapter 2: Project Description.

6.1.2 Competence

This Chapter has been prepared by Weetwood Services Limited (Weetwood). Weetwood is a water management and utilities consultancy serving the development industry across the UK. Weetwood has undertaken numerous EIAs in relation to the water environment to support a range of developments.

This Chapter has been written by Keely Bonser BSc (Hons) MSc PhD MCIWEM. Keely is a Director at Weetwood and has over 9 years of experience working in the water environment. Keely has extensive experience of managing and coordinating both small and large-scale projects and has produced numerous ES Chapters in support of a range of proposed developments and planning submissions including strategic development sites.

6.2 Methodology

6.2.1 Relevant Guidance

In preparing this Chapter, a wide range of national legislation and policy guidance documents relevant to the assessment have been considered as listed in Table 6.1.

Table 6.1: Relevant Key Legislation, Policies and Guidance Documents

Context	Legislation, Policies and Guidance Documents
National	The Water Environment (Water Framework Directive) (England and Wales) Regulations (2017)
	National Planning Policy Framework (updated July 2021)
	Planning Practice Guidance (updated August 2022)
	Water Industry Act (1991)
	Water Act 2003 (as amended) Flood and Water Management Act (2010)
	National Flood and Coastal Erosion Risk Management Strategy for England, Environment Agency (2020)

	Control of Pollution (Oil Storage) (England) Regulations (2001)
	Surface Waters [Dangerous Substances (Classification)] Regulations (1998)
	Control of Substances Hazardous to Health (COSHH) Regulations (2002)
	Environment Act 1995 (as amended)
	Surface Water (River Ecosystem) (Classification) Regulations (1994)
	Land Drainage Act 1991 (as amended)
	Food and Environment Protection Act (1985)
	Making Space for Water – Taking Forward a New Government Strategy for Flood and Coastal Erosion Risk Management in England, DEFRA (2005)
	Sustainable Drainage Systems (SUDS): Non-statutory Technical Standards for SUDS, DEFRA (2015)
	House of Commons Written Statement on SUDS (HCWS161) (2014)
	The Building Regulations - Drainage and Waste Disposal, Approved Document H, HM Government, Published in 2010, amended 2015
	TAG Unit A3 Environmental Impact Appraisal, Department for Transport (2014)
	Guidance on the Construction of SuDS (C768), CIRIA (2017)
	The SUDS Manual (C753), CIRIA (2015)
	SUDS: Hydraulic, Structural and Water Quality Advice (C609), CIRIA (2004)
	Control of Water Pollution from Construction Sites (C532), CIRIA (2001)
	Infiltration Drainage – Manual of Good Practice (CIRIA Report 156) (1996)
	Control of Pollution from Highway Drainage Discharges (CIRIA Report 142) (1994)
	Code of Good Agricultural Practice for the Protection of Water (DEFRA 1998, as amended 2002)
	Guidelines for the use of herbicides on weeds in or near watercourses and lakes, CIRIA (1995)
	Sewerage Sector Guidance Appendix C - Design and Construction Guidance v2.0 (2020)
County and Local	South-East Lincolnshire Local Plan 2011-2036 (2019)
Other Sources of Information	Strategic Flood Risk Assessment, South-East Lincolnshire (2017)
	Sustainable Drainage: Design and Evaluation Guide, Lincolnshire County Council (2018)

	The Wash Shoreline Management Plan 2 – Gibraltar Point to Old Hunstanton, The Wash SMP2, East Anglia Coastal Group (2010)
	Anglian River Basin District River Basin Management Plan (2015)
	Websites for Government, DEFRA and British Geological Survey

6.2.1.1 National Legislation and Planning Policy

The Water Framework Directive (WFD) provides a legal framework for the protection, improvement and sustainable use of inland surface waters, groundwater, transitional waters, and coastal waters across England. The WFD seeks to achieve at least ‘good’ status for all waterbodies.

Under the WFD, development must not result in any deterioration in the status of a waterbody nor compromise the aims of the WFD as set out in the River Basin Management Plans, for which the Environment Agency is the ‘competent authority’.

The Flood and Water Management Act 2010 implements several key recommendations of Sir Michael Pitt’s Review of the Summer 2007 flood.

The National Planning Policy Framework (NPPF) sets out the government's planning policies for England and how these are expected to be applied.

The NPPF guides local planning authorities and decision-takers both in drawing up plans and as a material consideration in determining applications. It includes policies to ensure that flood risk is taken into account at all stages in the planning process to avoid inappropriate development in areas at risk of flooding, and to direct development away from areas of highest risk (para. 162 of the NPPF). In exceptional circumstances where new development is necessary in areas at risk of flooding, the policy aims to make it safe, without increasing flood risk elsewhere, and, where possible, reducing flood risk overall (para. 163-165 of the NPPF).

The NPPF advocates the use of the risk-based Sequential Test to steer new development to areas at lowest probability of flooding. It also matches the flood risk vulnerability of a development proposal to appropriate flood zones and provides details on how to include the potential effects of climate change on development.

The NPPF states that major developments should incorporate sustainable drainage systems to appropriate operational standards and with maintenance arrangements in place unless there is clear evidence that this would be inappropriate (para. 169).

The NPPF is accompanied by the Planning Practice Guidance (PPG), which provides additional guidance to ensure the effective implementation of the policy set out in the NPPF.

6.2.1.2 Local Planning Policy

South-East Lincolnshire Council’s Local Plan 2011-2036 Policy 4 – Approach to Flood Risk sets out the Council’s aspirations for addressing flood risk and taking climate change into account and steering new development away from those areas at highest risk of flooding through applying the sequential test.

The Local Plan also references flood risk and Sustainable Drainage Systems (SuDS) in Policy 2, Policy 3 and Policy 31.

6.2.2 Study Area

The study area used for this assessment includes both the Application Site (hereafter referred to as the ‘Site’) and its nearby relevant hydrological features (extending 1 km from the Site as this is considered to be appropriate for the Site), including the catchments of local watercourses, surface water features and dependent habitats.

6.2.3 Baseline

The scope of the assessment has been based upon a review of available desktop information within the study area to identify the existing environment (baseline conditions) and development receptors. This has been supported by detailed assessments where necessary/required as detailed within this Chapter.

The Chapter utilises the results of the site-specific Flood Risk and Drainage Assessment (FRDA) (see Appendix 6.1 contained within Volume 2 of this ES) which has been prepared in accordance with relevant key legislation, policy and guidance documents, including the NPPF and the PPG.

Consultation has been undertaken with the Environment Agency and South Holland Internal Drainage Board (IDB). Details of consultations are outlined within the FRDA report (see Appendix 6.1 contained within Volume 2 of this ES).

6.2.4 Assessment Criteria and Assignment of Significance

6.2.4.1 Assessment Methodology

Surface and sub-surface receptors potentially susceptible to environmental effects from flooding and drainage issues associated with the Proposed Development have been identified as discussed below. The identification of receptors has been informed by an assessment of baseline conditions.

The presence, location and quality of surface water bodies at and within the vicinity of the Site and the risk of flooding from known sources have been assessed utilising Ordnance Survey, Government, Environment Agency and British Geological Survey data and mapping and the other sources of information listed in Table 6.1. The assessment of flood risk has also been informed by LIDAR and a site walkover.

In accordance with national and local planning policy and guidance (as set out in Table 6.1), and based upon professional experience and judgement, a package of measures to mitigate flood risk has subsequently been developed to ensure that the Proposed Development will be safe from flood risk for its lifetime, taking climate change and the vulnerability of its users into account.

A strategy for the management of surface water runoff has also been developed in accordance with planning policy and technical standards and the requirements of the WFD. The strategy has been informed by an assessment of the existing drainage regime at the Site utilising LIDAR data and geology mapping to define the topography of the Site and the underlying ground conditions. This information has in turn been utilised to inform the proposed means of disposal of surface water runoff from the Proposed Development.

6.2.4.2 Assessment of Significance

Informed by the baseline assessment, surface hydrology receptors of potential environmental effects have been identified (Table 6.5). The 'importance/sensitivity' of each receptor has been identified using professional judgement and by reference to the guidance criteria presented in Table 6.2.

The magnitude of impacts and potential significant effects on each receptor have been identified using the criteria presented in Table 6.3, informed by the baseline assessment, professional experience and stakeholder consultation.

Identified effects may be significant at the level of importance/sensitivity defined for the receptor, or at a lesser geographical scale. For example, limited effects on a watercourse of county value might be assessed as being significant at a district level. Thus, the significance of effects has been determined from the importance/sensitivity of the receptor, the magnitude of the change and, where appropriate, the likelihood of the effect occurring using the effect significance matrix presented in Table 6.4.

Potential effects may be assessed to be adverse or beneficial.

Mitigation measures have been developed for identified effects using technical guidance, best practices and professional experience. Where the significance of an effect (or effects) is assessed to be 'Negligible', no mitigation measures are considered to be necessary.

The magnitude of impacts following the application of the identified mitigation measures (i.e. the residual effect) has been assessed with reference to the extent, magnitude and duration of the impact and performance against environmental quality standards, again with reference to the criteria presented in Table 6.2. The significance of the residual (i.e. post mitigation) effects has been assessed as described above.

Table 6.2: Estimating Receptor Importance/Sensitivity

Importance/ Sensitivity	Criteria	Measures
Very High *National*	Receptor has a high quality and rarity on an international or national scale.	Surface Water: Designated Salmonid / Cyprinid fishery, High WFD Ecological status, Good WFD Chemical status, Protected under UK habitat legislation (e.g. Site of Special Scientific Interest, Water Protection Zone, Ramsar site). Waterbodies important at a national scale. Flood Risk Management: Essential infrastructure land uses such as essential transport and utility infrastructure.
High *Regional*	Receptor has a high quality on a county or regional scale	Surface Water: Major Cyprinid fishery, Good WFD Ecological status, Good WFD Chemical status, Species protected under UK habitat legislation. Waterbodies important at a regional scale. Flood Risk Management: Highly vulnerable land uses such as emergency services, caravans, mobile homes and park homes intended for permanent residential use, basement dwellings and installations requiring hazardous substances consent.
Medium *District/Local Authority*	Receptor has a medium quality on a local or district scale	Surface Water: Moderate WFD Ecological status, Good WFD Chemical status. Waterbodies important at a district/local scale. Flood Risk Management: More vulnerable land uses such as hospitals, residential units, hostels / hotels, non-residential uses for health services and waste management sites.
Low *Site*	Receptor has a low quality and rarity on a local scale	Surface Water: Poor/Bad WFD Ecological status, Poor WFD Chemical status. Waterbodies important at a site scale. Flood Risk: Less vulnerable land uses such as water-compatible developments, retail, commercial and general industrial units, agricultural / forestry sites and water/sewage treatment plants

Table 6.3: Criteria for Estimating the Magnitude of Change on a Receptor

Magnitude	Criteria	Measures
Major/High	A considerable effect (by extent, duration or magnitude) of the receptor	Surface Water: Significant change in WFD class, Significant change in pollution discharge, which may result in removal of likelihood of polluting discharge occurring or loss or extensive change to a fishery and loss or extensive change to a designated Nature Conservation Site. Flood Risk Management: Significant effect on flood risk. This may be an increase or decrease in flood depth, flood flow velocities or extent of flooding.
Moderate/Medium	Limited effects to receptor	Surface Water: Moderate change in WFD class, Medium risk of pollution from a spillage, Partial loss of productivity of a fishery. Flood Risk Management: Moderate change in flood risk. This may be an increase or reduction in flood depth, flood flow velocities or extent of flooding.

Minor/Low	Some minor change to receptor	Surface Water: Minor change in WFD class, Minor risk of pollution from a spillage. Flood Risk Management: Minor change in flood risk. This may be an increase or reduction in flood depth, flood flow velocities or extent of flooding.
Negligible	Effect on receptor but of insufficient magnitude to affect the use or integrity	Surface Water: Negligible or no risk of pollution from a spillage. Flood Risk Management: Negligible change in flood risk.

6.2.5 Significance of Effects

Likely effects are concluded to be major, moderate, minor or negligible. Professional judgement is used to determine effects which are likely to be significant. The italicised text in Table 6.4 represents those effects that are considered to be significant in terms of the EIA Regulations.

Table 6.4: Assessment of Significance Matrix

Importance/ Sensitivity	Magnitude of Impact			
	Negligible	Minor/Low	Moderate/Medium	Major/High
Low	Negligible	Negligible or Minor	Negligible or Minor	Minor
Medium	Negligible or Minor	Negligible or Minor	Minor	*Minor or Moderate*
High	Negligible or Minor	Minor	*Moderate*	*Moderate or Major*
Very High	Minor	*Minor or Moderate*	*Moderate or Major*	*Major*

6.3 Baseline Environment

The baseline conditions and outcomes of the FRDA (see Appendix 6.1 contained within Volume 2 of this ES) have informed this sub-chapter.

6.3.1 Surface Water

The Wash is located approximately 2.8 km to the north of the Site.

There is a network of drainage ditches, classified as High Priority and Ordinary watercourses, on and within the vicinity of the Site including Sot's Hole, Middle Drain, Fleet Haven Drain and Sot's Hole and Connection. Most of the drains fall under the jurisdiction of South Holland IDB (as shown in Figure 2 of the FRDA; see Appendix 6.1 contained within Volume 2 of this ES).

The Site falls within two drainage catchments within South Holland IDB:

- Lawyers – watercourses within the Lawyers catchment flow towards Lawyers pumping station approximately 3.5 km north of the Site where water is pumped to The Wash. The flow of water prior to Lawyers pumping station is controlled at Thimbleby Sluice and Salt Marsh Soke Dyke Sluice approximately 800 m south of Lawyers pumping station.
- Fleet Haven – watercourses within the Fleet Haven catchment are in part pumped from Manor Farm pumping station approximately 1.5 km to the south of the Site towards Middle Drain and Fleet Haven Drain. The flow of water in Fleet Haven Drain is controlled by Coffee Tan Sluice approximately 2.1 km north-east of the Site. Approximately 1.0 km north-east of the sluice, Fleet Haven pumping station pumps Fleet Haven Drain towards The Wash.

A number of unnamed drains are located on-site which flow into the IDB High Priority and Ordinary watercourses.

A small water impounded structure is located at Hartley Farm adjacent to the west of Sot's Hole and to the north of Sot's Hole and Connection. The small water impounded structure is used for irrigation purposes. A further small water impounded structure is located approximately 800 m to the south of the Site.

The Site is located within the Welland Lower Operational Catchment. There are no WFD defined surface water bodies within the vicinity of the Site which the Proposed Development would impact.

6.3.2 Flood Risk Management

6.3.2.1 Site Levels

LIDAR data has been used to develop a digital elevation model of the Site as illustrated in Figure 3 of the FRDA (see Appendix 6.1 contained within Volume 2 of this ES). Ground levels are shown to be flat with levels generally in the region of approximately 3.1 to 3.6 m AOD, with levels along watercourses in the region of approximately 1.5 to 2.0 m AOD.

6.3.2.2 Historical Records of Flooding

The Environment Agency Historic Flood Map, South Holland IDB and the 2017 Strategic Flood Risk Assessment do not hold any records of flooding at or within the immediate vicinity of the Site.

6.3.2.3 Flood Zone Designation

The Environment Agency Flood Map for Planning (see Figure 4 of the FRDA, Appendix 6.1 contained within Volume 2 of this ES) indicates the Site to be located in flood zone 3.

6.3.2.4 Flood Defences

The Site is defended from the sea by formal flood defences comprising of earth embankments along the shoreline supplemented by salt marsh to maintain foreshore levels. According to Environment Agency records, the defences within the vicinity of the Site are in fair condition, have a crest level of between 6.9 – 8.0 m AOD, and provide a 1 in 150 annual exceedance probability (AEP) standard of protection.

The Site is located in the Gibraltar Point to Old Hunstanton (The Wash) shoreline management plan and is covered by Policy Development Zone (PDZ) 1 (Gibraltar Point to Wolferton Creek).

The policy for PDZ1 requires continuation of the current levels of flood defence management, with established settlements continuing to be protected to the existing standard (i.e. 1 in 150 AEP).

6.3.2.5 Flood Risk from the Sea (Tidal/Coastal)

A comparison of the Environment Agency's extreme tide levels for Immingham to the West Lighthouse and the crest level of the flood defences, indicates that the Site is not at risk of flooding from the sea, including when taking climate change into account.

Still water levels do not account for wave action or other variables and detailed modelling has been undertaken by the Environment Agency to provide a more accurate representation of flood risk due to overtopping of the flood defences and a breach in defences taking into account these additional factors.

The modelling shows that the Site is not at risk of flooding due to overtopping of flood defences during the present day (2006) 1 in 200 and 1 in 1,000 AEP events and during the 1 in 200 AEP event plus climate change (2115), as illustrated in Figure 5 of the FRDA (Appendix 6.1 contained within Volume 2 of this ES).

The modelling shows that the Site would be expected to flood during the present day (2006) 1 in 200 and 1 in 1,000 AEP breach events up to a depth of 1.0 m. When taking climate change into account, flood depths would be expected to range between 0.5 – 1.6+ m (refer Figure 6 of the FRDA, Appendix 6.1 contained within Volume 2 of this ES).

Given the above, it is concluded that the Site is at a High risk of flooding from the sea (tidal/coastal) due to a breach in flood defences, although the likelihood of the defences failing is assessed to be low, and therefore the direct risk of flooding at the site is considered to be low.

6.3.2.6 Flood Risk from Rivers

A comparison of peak modelled water levels for the on-site watercourses and site levels indicates that peak flows would remain in channel during the 1 in 100 AEP event plus 20% climate change.

There is a risk of the pumping stations (including Lawyers, Fleet Haven and Manor Farm) failing, potentially rendering the site at a residual risk of flooding. However, South Holland IDB constantly monitor the pumping stations through the Board's telemetry system, with pumps being serviced every 8-10 years and major refurbishments occurring approximately every 30 years.

Based on the above, the Site is assessed to be at a Low risk of flooding from rivers (fluvial).

6.3.2.7 Flood Risk from Other Sources

The Flood Risk from Surface Water map (see Figure 7 of the FRDA, Appendix 6.1 contained within Volume 2 of this ES) indicates that the Site is predominantly at a Very Low risk of flooding from surface water (pluvial) and small watercourses.

There are no canals within the vicinity of the Site. The Flood Risk from Reservoirs map indicates that the Site is not at risk of flooding from such sources. The Site is assessed to be at a Low risk of flooding from the small water impounded structures located at Hartley Farm and approximately 800 m to the south of the Site.

The JBA Groundwater Flood Risk Indicator Map indicates that the Site is at a Negligible risk during a 1 in 100 AEP groundwater flood event.

6.3.2.8 Land Drainage

The Site comprises agricultural farmland. It is possible that field drains are present, but no other formal drainage infrastructure is believed to be present.

According to the Soilscapes soils dataset produced by the Cranfield Soil and AgriFood Institute, soil conditions at the site and within the surrounding area are described as loamy and clayey soils of coastal flats with naturally high groundwater.

British Geological Survey mapping of surface geology indicates the underlying bedrock formation comprises mudstone (Ampthill Clay Formation), overlain by superficial deposits of clay and silt (Tidal Flat Deposits).

According to the MAGIC website the underlying bedrock and superficial deposits are classified as Unproductive aquifers. The Site is not shown to be located within a designated groundwater source protection zone.

Given the Site topography and ground conditions, surface water runoff would be expected to slowly infiltrate where conditions allow and flow overland in a direction determined by topography.

6.3.2.9 Development Receptors

Table 6.5 lists the identified environmental receptors and their assessed importance/sensitivity using the criteria presented in Table 6.2 as guidance.

Table 6.5: Development Receptors

Impact	Receptor	Nature of Effect	Importance/Sensitivity of Receptor
Surface water: Water quality	IDB watercourses	Pollution risk	Medium
	Small water impounded structures	Pollution risk	Low
Flood risk management Inc. land drainage	Sea	Flood risk	Low
	IDB watercourses	Flood risk	Medium
	Small water impounded structures	Flood risk	Low

	Site workers and local residents (Construction phase only)	Flood risk	High
	Site employees and local residents (Operational phase only)	Flood risk	High

6.3.2.10 Future Baseline

The existing flood risk to the Site and surrounding area from all identified sources, and the quality of the receiving surface water bodies will remain as existing in the future, potentially improve or potentially deteriorate.

The committed or pending developments within the vicinity of the Site, which have been considered in the cumulative effects section of this Chapter, could affect the future baseline for surface water drainage and flood risk and this is therefore considered below.

In accordance with the NPPF and the supporting PPG, a site-specific Flood Risk Assessment (FRA) and/or Drainage Assessment (DA) should be undertaken in support of a planning application. This should include an outline surface water drainage strategy demonstrating how runoff will be managed so as not to increase flood risk elsewhere over the lifetime of the development (i.e. taking climate change into account), with betterment provided where possible. Appropriate mitigation should also be incorporated into the construction and operational phases of the committed scheme in order to ensure that surface water runoff is not contaminated and adversely affected.

Prior to the construction of all approved schemes, details of the mitigation measures addressing the above would need to be approved in writing by the local planning authority.

Recognising the above, the schemes would be expected to have a Negligible effect on surface water, flood risk and land drainage even in the event that all developments are operational. In turn this would be expected to have a Negligible effect on the future baseline scenario.

6.4 Impact Assessment

6.4.1 Assessment of Construction Effects

6.4.1.1 Surface Water

During the construction phase there would be a number of activities which could potentially directly reduce surface water quality. These include:

- Materials handling, storage, stockpiling, spillage and disposal;
- Earthworks involving manipulation of ground levels and re-engineering of existing made ground if / as necessary;
- Excavation and foundation construction within the site and site preparation;
- Installation of temporary and permanent infrastructure and roads;
- Installation of temporary site accommodation and sanitary facilities;
- Construction of proposed buildings;
- Construction/installation of surface water attenuation features;
- Formation of public spaces, public realm and associated restoration and landscaping; and
- Movement and use of static and mobile plant/construction vehicles.

Construction activities may lead to the disturbance and mobilisation of physical contaminants (i.e. dust, sediments and muds). During periods of heavy rainfall, vehicle movements resulting in damage to soil structure may generate increased sedimentation within surface water runoff. In addition, during periods of dry, windy weather, wind-blown dusts may be generated by the excavation of soils.

These activities may result in sediments directly or indirectly entering surface water features, thereby impacting the physical, chemical and biological quality of the surface water receptors in the surrounding area.

Contaminants, spilled contaminants and suspended sediments have the potential to impact surface water bodies via surface runoff.

The Proposed Development incorporates embedded mitigation as set out in section 6.4.5.1 below together with a detailed Construction Environmental Management Plan as summarised in section 6.4.5.2. The adoption of best practice construction methods and construction management processes would significantly mitigate many of the identified potential environmental effects of the construction phase of the Proposed Development.

6.4.1.2 Flood Risk Management and Land Drainage

Potential ponding of surface water and accidental runoff to the surrounding area may occur whilst the surface water drainage system is being constructed.

Soil compaction on Site may increase on and off-site flood risk.

The Proposed Development incorporates embedded mitigation as set out in section 6.4.5.1 below together with a detailed Construction Environmental Management Plan as summarised in section 6.4.5.2 that will be provided in advance of commencement. The adoption of best practice construction methods and construction management processes would significantly mitigate many of the identified potential environmental effects of the construction phase of the Proposed Development. In addition, the assessment of potential impacts on agriculture (ES, Volume 2, Appendix 10.1) confirms that the land will suffer less compaction during the operational phase of the Proposed Development than would be the case if the current agricultural practices were to continue.

In that context no further mitigation, enhancement or compensation, over and above the embedded mitigation detailed in Section 6.4.5.1 is deemed to be necessary for the operational phase.

6.4.1.3 Summary

The likely effects of the Proposed Development during the construction phase following implementation of the embedded mitigation (refer Section 6.4.5.1) but prior to the application of any additional mitigation measures are summarized in Table 6.6.

Table 6.6: Potential Effects During Construction Phase (Pre-Mitigation)

Impact	Receptor	Nature of Effect	Importance/ Sensitivity of Receptor	Duration	Magnitude of Change	Significance of Effect
Surface water: Water quality	IDB watercourses	Pollution risk	Medium	Short term	Minor adverse	Negligible, Not Significant
	Small water impounded structures	Pollution risk	Low	Short term	Negligible	Negligible, Not Significant
Flood risk management Inc. land drainage	Sea	Flood risk	Low	Short term	Negligible	Negligible, Not Significant
	IDB watercourses	Flood risk	Medium	Short term	Negligible	Negligible, Not Significant
	Small water impounded structures	Flood risk	Low	Short term	Negligible	Negligible, Not Significant

	Site workers and local residents	Flood risk	High	Short term	Negligible	Negligible, Not Significant

6.4.2 Assessment of Operational Effects

6.4.2.1 Surface Water

The increase in impermeable area from the Proposed Development could potentially increase the risk of contamination of surface runoff due to the flushing of pollutants from the impermeable surfaces.

Contaminated surface runoff could enter local surface water bodies via overland flow and/or infiltration.

Over time, dirt and dust may accumulate on the glass surface of the modules, reducing the power output of the module. It is recommended by the manufacturers that regular cleaning of the modules is undertaken to ensure maximum power output.

There is no requirement to use any local water resources as de-ionized water will be brought to site. In some instances, alcohol or glass cleaner may be used to remove some oily deposits but this will be sprayed onto the panel surface by hand and will be localised in nature. There will be no other chemicals used on site.

In that context the impact of panel cleaning is likely to be of **negligible** magnitude the environmental impact is assessed as **negligible.**

6.4.2.2 Flood Risk Management and Land Drainage

Any development or raising of ground levels within areas considered to be at risk of flooding has the potential to increase flood risk to people, property and elsewhere in the local catchment by displacing floodwaters and flood storage during times of flooding.

However, the layout of the Proposed Development has been informed by the existing topography and landscape features. To protect against damage to landscape features the layout has evolved to include a buffer zone between existing hedgerows and solar panels. Internal access tracks will utilise existing field openings where possible.

There will be no cut and fill or regrading of land to facilitate panel placement and excavation is only required for cable laying and access tracks as well as inverter and substation bases. This constitutes a minimal percentage of the site area.

If unattenuated, the increase in the extent of impermeable area at the Site could potentially increase the rate of surface water runoff and total runoff volumes to the surrounding area and in turn the level of flood risk.

The solar panels will not form large impermeable surfaces. The front bottom edge of the panels will be typically 0.8m above existing ground level and within a range of 500mm to 1.2m, depending on local topography. The rear of the panels will be raised between 1.8 and 3m above the ground. The arrays are arranged in well-spaced rows with open avenues in between, measuring approximately 3m in width. In addition, there are spaces between each of the panels as they are affixed to the supporting structure, allowing rainwater to pass through the arrays and disperse evenly. These design features combine to ensure permeability within the solar panels, and runoff will be no greater for the developed site than it is for the pre-developed site. Rainfall will fall onto open ground as usual or run-off the panels through the gaps into the ground to be dispersed by the same routes that are currently in place.

A recent research paper ‘Hydrologic Response to Solar Farms’ (Cook and McCuen, Journal of Hydrologic Engineering, 2013) examined the effect of solar panel sites on surface runoff. A model was created to simulate stormwater runoff over a land surface without panels and then with solar panels added. Results found that the addition of solar panels over a grassy field does not have much of an effect on the volume of runoff, the peak discharge or the time taken for runoff to peak. Their analysis did find that with bare ground or gravel cover beneath the panels, peak discharge may increase resulting in the need for storm management.

The embedded mitigation proposals include sowing of a permanent grass sward below the solar tables. Grass cover helps reduce runoff and erosion by slowing movement of water in the affected area which is a benefit over the current arable nature of the Site. Earth disturbance and grading activities will be minimised. This will therefore replicate the pre-development condition after the construction is finished.

The site is gently sloping so there are no steep slopes that could cause significant runoff paths to develop. If the infiltration rate of the soil is exceeded the velocity of any standing water that does begin to form will be slow, giving a greater likelihood that it will be absorbed by the drier land under the panels.

Any flows that do not infiltrate will drain to the existing drainage ditches within the site. The overall drainage regime for the site will not therefore be significantly altered as a result of the proposed development. Any new crossings of watercourses could increase flood risk due to potential restriction in channel conveyance capacity.

Any such crossings will be designed in agreement with the Drainage Authority which will ensure that any prospect of increased flood risk is minimised.

6.4.2.3 Summary

The likely effects of the Proposed Development during the operational phase following implementation of the embedded mitigation (refer Section 6.4.5.1) but prior to the application of any additional mitigation measures are summarized in Table 6.7.

Table 7: Potential Effect During Operational Phase (Pre-Mitigation)

Impact	Receptor	Nature of Effect	Importance/ Sensitivity of Receptor	Duration	Magnitude of Change	Significance of Effect
Surface water: Water quality	IDB watercourses	Pollution risk	Medium	Long term	Minor adverse	Negligible, Not Significant
	Small water impounded structures	Pollution risk	Low	Short term	Negligible	Negligible, Not Significant
Flood risk management Inc. land drainage	Sea	Flood risk	Low	Long term	Negligible	Negligible, Not Significant
	IDB watercourses	Flood risk	Medium	Long term	Minor	Negligible, Not Significant
	Small water impounded structures	Flood risk	Low	Short term	Negligible	Negligible, Not Significant
	Site employees and local residents	Flood risk	High	Long term	Minor adverse	Minor adverse, Not Significant

6.4.3 Assessment of Cumulative Effects

In accordance with the NPPF and the supporting PPG, a site-specific FRDA has been undertaken for the Proposed Development. Other committed or pending schemes under consideration by the local planning authority should also undertake a FRA and/or DA as part of its respective planning application. This should include an outline surface water drainage strategy demonstrating how runoff will be managed so as not to increase flood risk elsewhere, with betterment provided where possible. Appropriate mitigation should also be incorporated into the construction and operational phases of the committed scheme in order to ensure that surface water runoff is not contaminated.

Prior to the construction of all approved schemes, details of the mitigation measures addressing the above would need to be approved in writing by the Local Planning Authority (South Gloucestershire Council).

Recognising the above, the schemes would be expected to have a negligible effect on surface water, flood risk and land drainage. In turn, this would be expected to have a negligible effect on the Proposed Development.

6.4.4 Mitigation

6.4.5.1 Embedded Mitigation

The risk of flooding to the Proposed Development from all identified sources is assessed to be negligible or low (albeit there may be a residual risk of a breach of the coastal/tidal flood defences). Notwithstanding this, any residual risk will be mitigated through the implementation of the following measures:

- Existing drainage ditches to be retained.
- No substations, inverter stations or storage containers proposed within 9 m of the top of bank of existing drainage ditches.
- The area under the panel drip line to be seeded with a suitable grass mix to prevent rilling and an increase in surface water runoff rates.
- Panelled part of the site to comprise managed grassland.
- Any new access crossings on existing drainage ditches to be designed to maintain existing conveyance capacity.

As set out in section 6.4.2.2 above, experience shows that solar panels do not significantly increase surface water runoff. The sowing of grass sward beneath the solar arrays will act as embedded mitigation in controlling runoff than would be the case with continued arable agricultural practice. Surface water runoff from the Proposed Development will therefore be managed in a sustainable manner to mimic the surface water flows arising from the Site prior to the Proposed Development.

The Site is currently used for agricultural purposes. Following completion, land use will be for a solar farm for a period of 40 years. As such, there will be a reduction in the use and polluting effects of fertilisers during this period.

A surface water drainage strategy is presented in Section 5 of the FRDA report (see Appendix 6.1 contained within Volume 2 of this ES). The design principles of the strategy comprises the following:

Panelled Areas of the Solar Farm

- Given that the Site is virtually flat, and that the Proposed Development is to include managed grassland beneath the solar panels, the impact on runoff rates and volumes from the panelled part of the development is assessed to be negligible. As such, no specific drainage for the panelled part of the Site is proposed.
- Existing access tracks will be utilised where feasible and will therefore continue to drain as per the current arrangement.
- The inverter stations have relatively small impermeable areas. It is recommended that an infiltration trench is implemented alongside one edge of each inverter/transformer station which is located adjacent to an existing track as to promote infiltration into the ground.

Access Tracks and Other Areas of Hardstanding

- The Site is underlain by soils with impeded drainage. As such, the disposal of surface water via infiltration is unlikely to be feasible. It is subsequently proposed to direct all runoff from hardstanding areas within the Site to the IDB watercourses located on-site.
- It is proposed to restrict surface water runoff to 1.4 l/s/ha, however, it is recognised that a flow control with a diameter of less than 50 mm may pose a risk of blockage to the drainage system.
- Attenuation storage will be provided to store runoff from contributing areas i.e. new access tracks, inverter stations, sub-station, battery storage compound for units and construction compound.
- Attenuation storage facilities have been sized to store the 1 in 100 AEP event including a 40% increase in rainfall intensity in order to allow for climate change.
- The storage volume could be accommodated within a Type 3 sub-base material within the compound area and access tracks at a depth of 0.3 m.
- SuDS components would be used as part of the surface water drainage system to provide the necessary surface water attenuation required to restrict runoff rates from the proposed impermeable areas. SuDS are designed to both manage the environmental risks resulting from urban runoff and contribute wherever possible to environmental enhancement. Therefore, SuDS objectives are to

minimise the effects from a development on the quantity and quality of runoff and maximise amenity and biodiversity opportunities. The use of SuDS within the Proposed Development would reduce pollutant concentrations in stormwater, thus protecting the quality of the receiving waterbody and would also act as a direct buffer for accidental spills by preventing a direct discharge of high concentrations of pollutants to the receiving waterbody.

An indicative drainage layout presenting the key SuDS infrastructure is provided in Appendix G of the FRDA report (see Appendix 6.1 contained within Volume 2 of this ES).

6.4.5.2 Construction Mitigation

Potential effects on the water environment through the construction phase would be managed by a range of operational, control and monitoring measures that, as a whole, would act to mitigate the potential effects on surface water, flood risk and land drainage.

As a matter of course the following would occur; note the principal contractor may use alternative procedures compliant with their own environmental management system. However, the broad approach and content would as a minimum be comparable to the following:

- A Construction Environmental Management Plan (CEMP) or equivalent would be prepared, submitted by the principal contractor and agreed with the local planning authority. The CEMP will set out the methods, including the minimum requirements as agreed between the construction contractor and the local planning authority, by which construction will be managed to avoid, minimise and mitigate any adverse effects on the water environment. The CEMP should cover: Site security; Fuel oil storage, bunding, delivery and use; How both minor and major spillage will be dealt with; Containment of silt / soil contaminated runoff; Disposal of contaminated drainage, including water pumped from excavations; and Site induction for workforce highlighting pollution prevention and awareness;
- All construction works would be designed in accordance with the latest relevant guidelines;
- Contractors undertaking earthworks would develop risk assessments and method statements covering all aspects of their work that have the potential to cause physical damage to structures (e.g. sewerage infrastructure), mobilise large quantities of soil / sediments or block open watercourses. Earth moving operations would be undertaken in accordance with BS 6031: 2009 Code of Practice for Earthworks. These would be incorporated within the CEMP;
- Works affecting soils would follow good practice guides for handling soils which would provide guidance on the use, management and movement of soil on Site;
- Good practice guidance on erosion and pollution control would be followed, e.g. CIRIA Environmental Good Practice on Site (C650) and Control of Water Pollution from Construction Sites (C532);
- The principal contractor would avoid the storage of plant, machinery fuel or materials (including soil stockpiles) alongside watercourses unless unavoidable. Construction works should be programmed as far as is practicable to minimise soil handling and temporary soil storage; and
- The refuelling of plant, storage of fuels and chemicals and overnight storage of mobile plant would be within the designated contractor's compound areas. The compounds would contain appropriate facilities for the storage of fuels and chemicals i.e. bunded and locked storage containers, and would also be equipped with spill kits.

The adoption of best practice construction methods and construction management processes will significantly mitigate many of the identified potential environmental effects of the construction phase of the Proposed Development.

Surface water runoff during the construction phase will be carefully controlled through application of measures outlined in the CEMP, including pollution prevention control.

Foul water from the temporary staff welfare facilities would be contained within sealed storage vessels and disposed of off-site to minimise the risk of surface water contamination. Welfare facilities would only be used for the disposal of domestic wastewater.

The principal contractor would avoid the storage of plant, machinery or materials in areas at risk of flooding wherever possible.

6.4.5.3 Operational Mitigation

No further mitigation, enhancement or compensation, over and above the embedded mitigation detailed in Section 6.4.5.1 is deemed to be necessary for the operational phase.

6.4.5 Future Monitoring

It is envisaged that no future monitoring is deemed necessary from a flood risk and drainage perspective.

6.4.6 Summary of Effects & Conclusion

The magnitude of change during the construction and operational phases following the application of the embedded mitigation and identified mitigation measures (i.e., the residual effect) has been assessed with reference to the extent, magnitude and duration of the effect; performance against environmental quality standards and other relevant criteria; receptor sensitivity and compatibility with environmental policies.

6.4.7.1 Construction Phase

The potential effects on the water environment during the construction phase of the Proposed Development will be managed through a range of control and monitoring measures that, as a whole, will act to mitigate the potential effects on surface water, flood risk and land drainage.

The adoption of best practice construction methods and construction management processes will mitigate the potential environmental effects of the construction phase of the Proposed Development and therefore the Proposed Development will have a Negligible, Not Significant residual effect on the water environment.

Table 6.8 provides a summary of the significance of effects resulting from the Proposed Development following implementation of the mitigation measures identified in this Chapter.

Table 6.8: Residual Effects During Construction Phase (Post-Mitigation)

Impact	Receptor	Nature of Effect	Importance /Sensitivity of Receptor	Duration	Significance of Effect; Pre-Mitigation	Mitigation	Residual Significance of Effect
Surface water: Water quality	IDB watercourses	Pollution risk	Medium	Short term	Negligible, Not Significant	Operational, control and monitoring measures including a CEMP	Negligible, Not Significant
	Small water impounded structures	Pollution risk	Low	Short term	Negligible, Not Significant		Negligible, Not Significant
Flood risk management Inc. land drainage	Sea	Flood risk	Low	Short term	Negligible, Not Significant		Negligible, Not Significant
	IDB watercourses	Flood risk	Medium	Short term	Negligible, Not Significant		Negligible, Not Significant
	Small water impounded structures	Flood risk	Low	Short term	Negligible, Not Significant		Negligible, Not Significant

	Site workers and local residents	Flood risk	High	Short term	Negligible, Not Significant		Negligible, Not Significant

6.4.7.2 Operational Phase

The risk of flooding to the Proposed Development from all identified sources is assessed to be negligible or low (albeit there may be a residual risk of a breach of the coastal/tidal flood defences).

No further mitigation, enhancement or compensation, over and above the embedded mitigation detailed in Section 6.4.5.1 is deemed to be necessary for the operational phase.

The implementation of the embedded mitigation including flood risk mitigation measures, change in land-use and an appropriately designed surface water drainage scheme, including the storage and controlled release of surface water and the provision of SuDS facilities will provide betterment in respect of surface water quality and flood risk.

The Proposed Development therefore has the potential to have a Minor Beneficial effect on surface water in respect of the local area, with a Negligible, Not Significant residual effect on the water environment.

Table 6.9 provides a summary of the significance of effects resulting from the Proposed Development following implementation of the mitigation measures identified in this Chapter.

Table 6.9: Residual Effects During Operational Phase (Post-Mitigation)

Impact	Receptor	Nature of Effect	Importance /Sensitivity of Receptor	Duration	Significance of Effect; Pre-Mitigation	Mitigation	Residual Significance of Effect
Surface water: Water quality	IDB watercourses	Pollution risk	Medium	Long term	Negligible, Not Significant	No further mitigation over and above the embedded mitigation (including a surface water drainage strategy and a change in land-use) is deemed to be necessary	Negligible, Not Significant
	Small water impounded structures	Pollution risk	Low	Short term	Negligible, Not Significant		Negligible, Not Significant
Flood risk management Inc. land drainage	Sea	Flood risk	Low	Long term	Negligible, Not Significant	No further mitigation over and above the embedded mitigation (including flood risk mitigation measures and a surface water drainage	Negligible, Not Significant
	IDB watercourses	Flood risk	Medium	Long term	Negligible, Not Significant		Negligible, Not Significant
	Small water impounded structures	Flood risk	Low	Short term	Negligible, Not Significant		Negligible, Not Significant

	Site workers and local residents	Flood risk	High	Long term	Minor, Not Significant	strategy) is deemed to be necessary	Negligible, Not Significant

6.5 Limitations of the Assessment

An assessment of the potential effects of the development has been undertaken based on a site visit and utilising the best data, methods and scientific knowledge available at the time of writing this Chapter.

6.6 References

- Department for Levelling Up, Housing and Communities and Local Government (2012), 'National Planning Policy Framework', available at: https://www.gov.uk/government/publications/national-planning-policy-framework--2
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- Environment Agency Flood Map for Planning, available at: https://flood-map-for-planning.service.gov.uk/
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