



Low Farm, Flockton Green Flood Risk Assessment & Drainage Strategy

For AARDVARK EM Limited

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1. INTRODUCTION

This report has been prepared by Hydrock Consultants Limited (Hydrock) on behalf of our client AARDVARK EM Limited in support of a Planning Application for proposed solar farm development on the land of Low Farm, Flockton Green, West Yorkshire.

Whilst the site is located within Flood Zone 1, the total site area exceeds 1 hectare and therefore, under National Planning Guidance, a Flood Risk Assessment is required.

This FRA report has been prepared to address the requirements of the National Planning Policy Framework (NPPF), through:

- Assessing whether the site is likely to be affected by flooding.
- Assessing whether the proposed development is appropriate in the suggested location.
- Presenting any flood risk mitigation measures necessary to ensure that the proposed development and occupants will be safe, whilst ensuring flood risk is not increased elsewhere.

2. SITE INFORMATION

2.1 Site Location

The site is located on Low Farm, Flockton Green approximately 10km south west of Wakefield, West Yorkshire. The proposed development is spread across nine parcels of land (see Figure 1 for numbered parcel locations) with numbers 1-3 & 7-9 located north of the A642 and parcels numbered 4-6 located south of the A642. The majority of parcels are bound by undeveloped open fields and woodland with the residential area of Flockton and Flockton Green located south of parcels 4-6.

Current site access to the majority of the land is from existing field access points (gated) and off the A642 or via farm access roads.

The site address for Low Farm and Ordnance Survey Grid Reference is provided in Table 1, with site / plot boundaries and locations shown in Figure 1.

Site Referencing Information	
Site Address	Low Farm, Wakefield Road, Grange Moor, Wakefield, West Yorkshire WF4 4BB
Grid Reference	SE246161 424642,416120

Table 1. Site Referencing Information

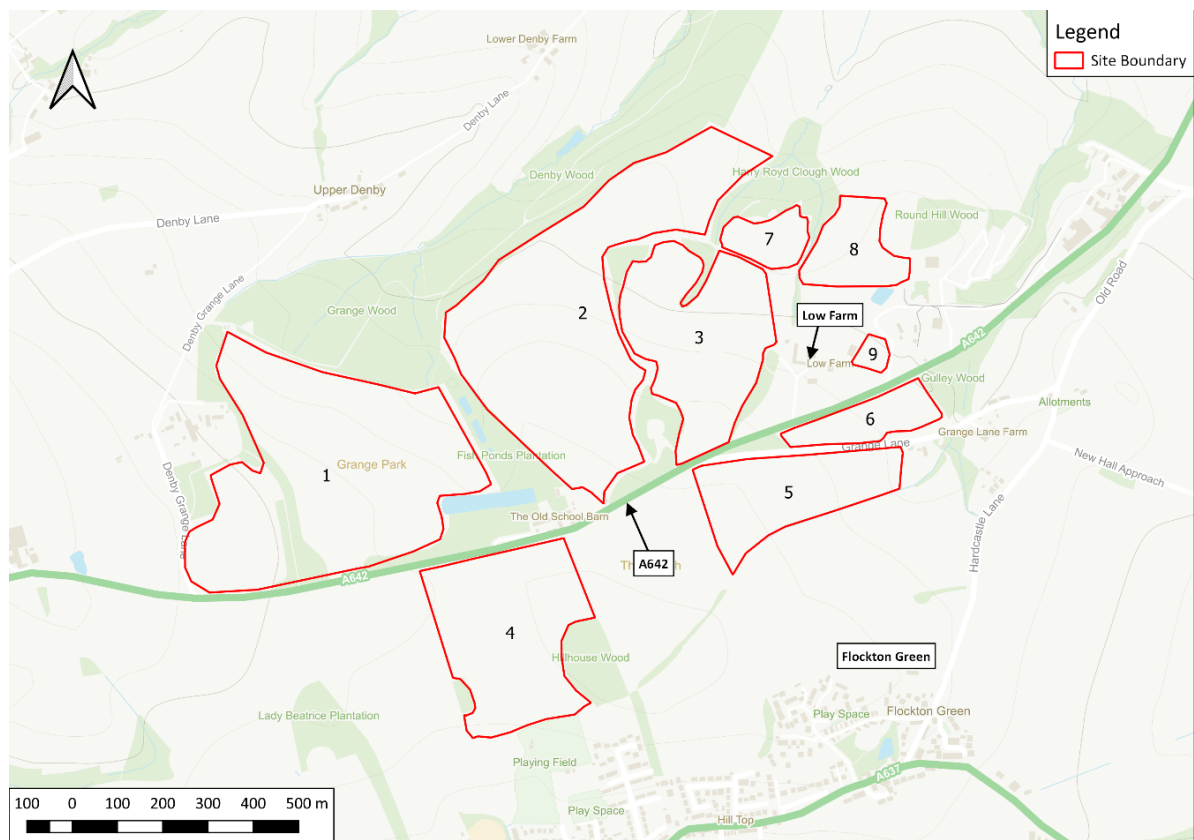


Figure 1. Site Location

2.2 Topography

A detailed topographical survey has been undertaken for the site by Survey Solutions (March 2021), a summary of this survey for each parcel is below.

- » Parcel 1 is shown to have a general easterly fall from a high point of approximately 210m AOD to a low point of 165m AOD in the eastern corner.
- » Parcels 2, 3 and 7 show a general north easterly fall with levels ranging from a high of approximately 180m AOD in the southern corner of Parcel 2, to a low point of approximately 120m AOD in the north east corner.
- » Parcel 4 shows a slight southerly fall from approximately 190m AOD along the northern boundary with the A642 to a low point of approximately 180m AOD in the south west corner.
- » Parcels 5, 6 and 9 are shown to have a general easterly fall from a high point of approximately 185m AOD in the western corner of Parcel 5, to a low point of approximately 150m AOD in the east of Parcel 9 150m AOD.
- » Parcel 8 shows a slight fall in a north westerly direction from a high point of approximately 145m AOD to a low point 130m AOD in the north west corner of site.

A copy of the topographical survey has been included within the planning submission.

2.3 Current Site Use

All parcels of land are currently either open fields laid to grass or mixed agricultural but all are undeveloped.

2.4 Proposed Development

The proposal is for a large-scale solar farm development spread across all nine parcels of land totalling 210.3 Acres.

Proposed site plans are included within the planning application.

3. INTRODUCTION

3.1 Fluvial Flooding

The closest watercourses to the site are two unnamed tributaries of the Smithy Brook. The first (referred to as Unnamed Watercourse 1) is located approximately 100m north of Parcel 2 and flows in a general north easterly direction towards the Smithy Brook around 1km to the north east. The second tributary (shown on Figure 3 as Unnamed Watercourse 2) runs in between Parcels 2, 7 and 8 and, like Unnamed Watercourse 1, flows in a generally north easterly direction. The Smithy Brook flows in an easterly and joins the River Calder approximately 3.5km to the east.

Approximately 0.5km to the south of Parcel 4 is the Mill Beck which flows generally south east and joins the River Dearne.

EA Flood Zone Mapping (Figure 4) shows the entire Low Farm site to be within Flood Zone 1 (Low Risk) with the closest identified Flood Zone area (Flood Zone 2) located approximately 0.5km south of Parcel 4 and associated with the Mill Beck.

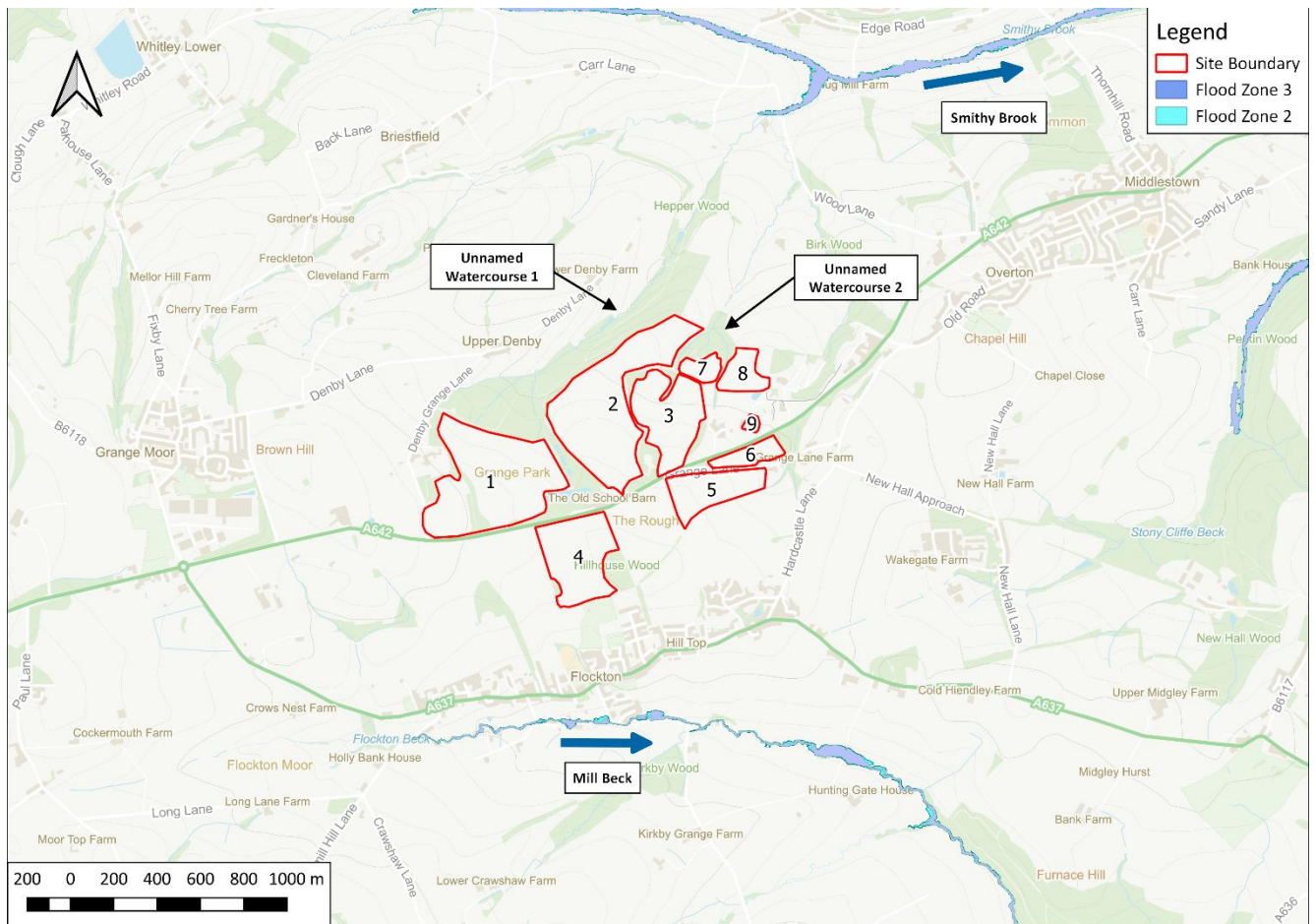


Figure 2. EA Flood Zone Mapping
 Contains OS data © Crown copyright (2020) and Environment Agency data under OGLv3

For reference, the Environment Agency Flood Zones are defined as follows:

- Flood Zone 1 (Low Risk) comprises land assessed as having a $\leq 0.1\%$ AEP (Annual Exceedance Probability) of fluvial flooding in any given year, equivalent to the $\geq 1,000$ yr return period flood event.
- Flood Zone 2 (Medium Risk) comprises land assessed as having a 0.1-1% AEP of fluvial flooding in any given year, equivalent to the 1,000-100yr return period flood event.
- Flood Zone 3 (High Risk) comprises land assessed as having a $\geq 1\%$ AEP of fluvial flooding in any given year, equivalent to the ≤ 100 yr return period flood event.

Neither the EA nor the Calder Catchment Strategic Flood Risk Assessment (SFRA) (JBA, 2016) identifies the site or surrounding area as having been impacted by any previous incidents of fluvial flooding.

Whilst the site is shown as being entirely within Flood Zone 1 it should be noted that the EA typically provide flood zonation outlines only for watercourses with a catchment of 3km^2 or greater. This is relevant as the catchments of the unnamed tributaries of the Smithy Brook up to the point before the confluence with the Smithy Brook (as taken from the CEH web mapping) are less than 3km^2 .

Given the size of these two catchments and the assumption that modelling is not currently available for the watercourses, it is considered that the EA's Flooding from Surface Water Mapping (see Figure 4 below) is a good indication of the worst case (i.e Flood Zone 2) outlines for flood risk associated with the unnamed watercourses as peak levels will be largely the result of local surface water flows.

EA Surface Water Mapping (Figure 4) confirms the majority of the Parcels sit outside the maximum flood extents from the unnamed watercourses, and therefore within Flood Zone 1. However, a small section to the north of Parcel 1 is shown to be at predicted risk. EA Online mapping indicates the flooding in this parcel to be below 300mm and therefore 'shallow', and it could therefore be classified as sheet flow that will likely travel with the prevailing topography away from site.

Whilst the potential effects of climate change could increase frequency, depth and extent of fluvial flooding, given the small catchment size of the streams to the north and south, any increase in flood risk is considered unlikely to be of a magnitude so as to result in on-site fluvial flooding. The site can therefore be concluded to be at 'low' risk of fluvial flooding.

3.2 Tidal Flooding

It should be noted that the EA Flood Zone Mapping does not distinguish between fluvial and tidal flood risk. Based on the raised elevation of the sites ($>120\text{m}$ AOD), inland geographical location, and the distance from any tidally influenced waterbodies, the risk of tidal flooding at the site is concluded to be 'low'.

3.3 Surface Water Flooding

Surface water flooding occurs as the result of an inability of intense rainfall to infiltrate the ground. This often happens when the maximum soil infiltration rate or storage capacity is reached. Flows generated by such events either enter existing land drainage features or follow the general topography which can concentrate flows and lead to localised ponding/flooding.

The EA Surface Water Mapping (Figure 3) shows the majority of the nine parcels of land to be at 'very low' risk of flooding from surface water. It does however indicate some flooding in between the parcels, following the local topography, which is likely an indication of fluvial flows and has been discussed in

Section 3.1. The mapping also identifies some localised ponding being predicted within Parcels 3, 4, 5 and 6 which show no connectivity to the wider surface water flow routes and are therefore indicative of locally lower lying areas. In the north of Parcel 1, the mapping also indicates an area of increased risk within the parcel boundary, however, as this shows connectivity to Unnamed Watercourse 1 this is considered as being a fluvial risk and has been discussed in Section 3.1.

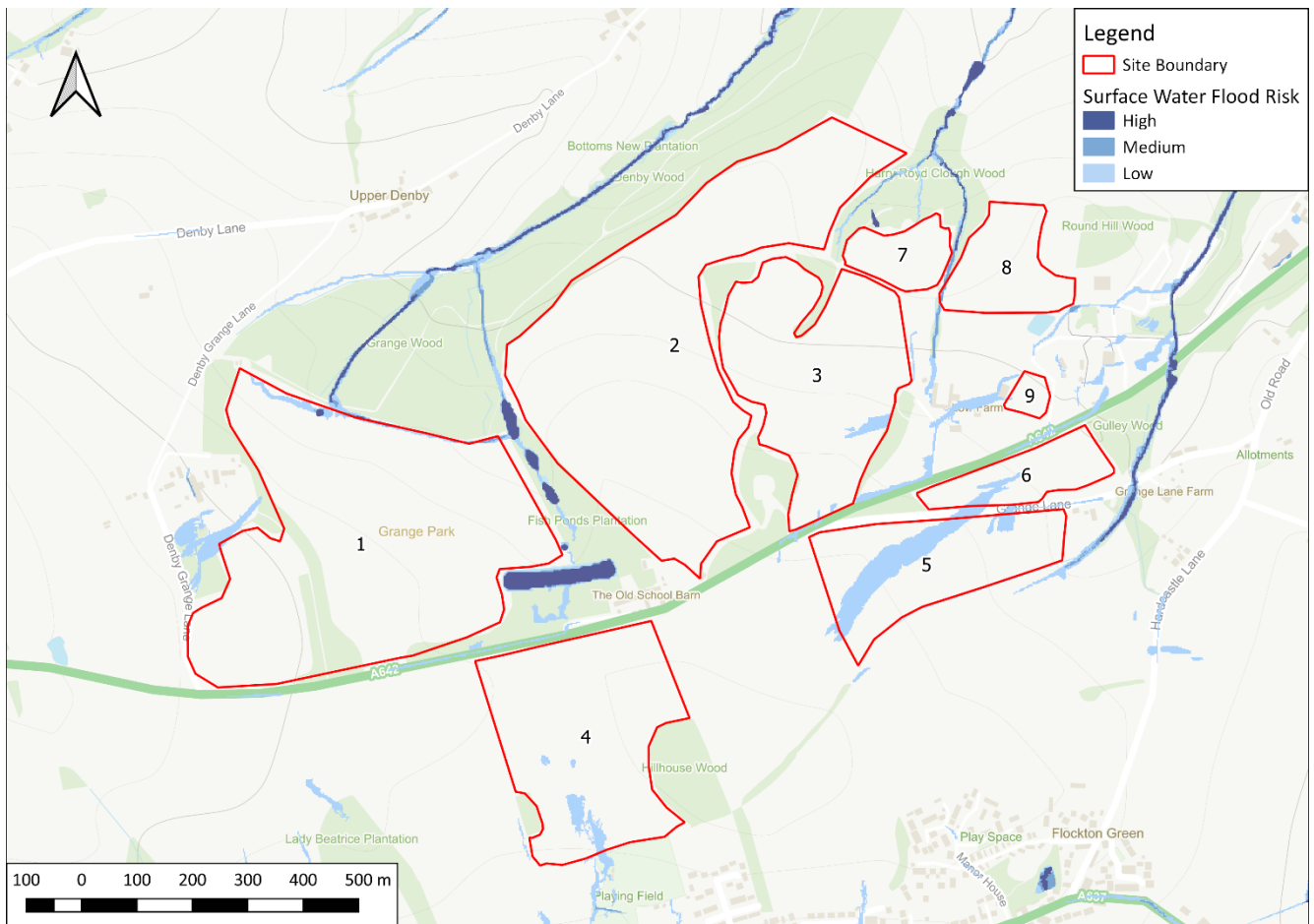


Figure 3. EA Surface Water Mapping
 Contains OS data © Crown copyright (2020) and Environment Agency data under [OGLv3](#)

The EA’s Long Term Flood Risk Mapping indicates the depths of the identified flooding in Parcels 3-6 to be shallow and ‘below 300mm’, and likely to be associated with local depressions or channels.

The SFRA does not highlight the site to be within an identified Critical Drainage Area (CDA) and indicates Flockton to have a low Surface Water Risk in terms of Number of Properties Affected. The report does not indicate any recorded incidents of pluvial flooding at the site or in the near vicinity to any parcel of land within the site.

Given the shallow depths indicated to impact Parcels 3-6, any surface water will likely travel as sheet-flow with the prevailing topographies, and as the remaining parcels sit outside any large 'high' risk areas it can be concluded that the risk of surface water flooding to the site is low.

Whilst the potential effects of climate change could increase the frequency, depth and extent of on-site surface water flooding, given the sloping topographies, any increase in flood risk is considered unlikely to be of a magnitude which would result in a significant increase in the risk of on-site surface water flooding, as any surface water run-off will likely continue to be directed overland as shallow 'sheet-flow'

risk of groundwater flooding posed to the site is considered unlikely to increase as a result of climate change.

3.5 Infrastructure Failure Flooding

The nature of the existing site and adjacent developments means it is unlikely there is an extensive drainage system serving the area, with any drainage systems likely limited to the surrounding road networks. Any surcharging of sewer networks will likely follow surface water flow routes and be directed through the site following local topographies. The generally consistent gradient through the parcels suggests that any such flows would be 'sheet flow', shallow in nature and ultimately directed away from the site (i.e. no localised ponding).

The SFRA does not identify any previous incidents of sewer flooding at the site or in the surrounding vicinity and therefore, given that the risk of sewer flooding is likely only in the event of failure or blockage, this is considered to be a 'residual' risk, and as such the risk of potential flooding from sewers is concluded to be 'low'.

The EA Reservoir Failure Extent mapping (EA, 2020)¹ does not show the site to lie within the extent of potential reservoir flooding and, given there is no known risk of flooding from canals or any other artificial sources at the site, it can be concluded that the risk of flooding from infrastructure failure is 'low'.

¹ EA Long Term Flood Risk Maps - <https://flood-warning-information.service.gov.uk/long-term-flood-risk/map>

4. NATIONAL PLANNING POLICY FRAMEWORK

4.1 Sequential & Exception Tests

This assessment has demonstrated that the site is on land designated as Flood Zone 1 by the EA's Flood Zone Mapping, and is at low or negligible risk of flooding from all other potential sources.

Paragraph 033 of the Flood Risk and Coastal Change National Planning Practice Guidance (NPPG) states that “*Nor should it normally be necessary to apply the Sequential Test to development proposals in Flood Zone 1*”.

The NPPG Flood Risk Vulnerability and Flood Zone Compatibility matrix (Table 3 of the NPPG) also indicates that all forms of development are "appropriate" in Flood Zone 1 without application of the Exception Test.

Accordingly, the application of the Sequential and Exception Tests is concluded to not be required in this instance.

4.2 Mitigation Measures

Whilst an Exception Test is not explicitly required under the NPPG, the following section details any measures recommended to mitigate any 'residual' flood risks and to ensure that the proposed development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, akin to the requirements of section 'b' of the Exception Test as outlined in the NPPF.

4.2.1 *Finished Floor Levels.*

Given the low risk of surface water flooding identified in Parcels 3-6 it is recommended best practice for the proposed solar panels to be elevated above surrounding ground levels a minimum of 0.8m where practicable to address any residual risk of surface water flooding.

It is recommended that, where practicable, the finished floor levels (FFL) of any sub-station or transformers are set above the adjacent ground levels by a minimum of 300mm either by raising the floor level above proposed ground levels or sloping ground levels away from the building. This will address any residual risks of surface water or sewer flooding (e.g. blockage of the proposed drainage network serving the site or exceedance of the drainage design capacity) by directing runoff away from or around the building.

4.2.2 *Safe Access and Egress*

The majority of the parcels are accessed via exiting entrances or farm access roads off the A642 with Parcels 5 and 6 accessed off Grange Lane. All access roads are indicated to be at low risk of flooding from all assessed sources and as such, safe access and egress is concluded to be possible to and from the site.

4.2.3 *Floodplain Storage*

On the basis that the site has been demonstrated to be at low risk of flooding, and therefore outside a functioning floodplain, the proposed development is not considered to increase flood risk within the catchment through a loss of floodplain storage, and accordingly no further mitigation measures are required in this respect.

5. SURFACE WATER DRAINAGE

5.1 Pre-development

Currently, no positive surface water drainage system serves any of the parcels of land, and therefore rainfall will likely preferentially infiltrate to ground (albeit noting the low permeability of the geological conditions at the site, infiltration is expected to be limited). In the scenario that the infiltration capacity of the site is exceeded (i.e. as a result of prolonged and/or intense rainfall), any surface water run-off will likely be directed overland as shallow 'sheet flow' with the prevailing topographies to the shallow valleys running adjacent to the parcels. Flows will then likely be conveyed away from the site by the existing ditches, Unnamed Watercourses 1 and 2 and the Smithy Brook.

5.2 Post-development

5.2.1 *Proposed Solar Photovoltaic Panels*

Whilst a portion of the site will comprise proposed solar photovoltaic panels, the remainder of the site area will comprise spacing between rows, field margins, and retained hedgerows. The nature of solar photovoltaic panel arrays means that the area represented by the proposed panels is not considered impermeable, as the ground beneath all panels will remain permeable. Rainfall will drain freely off the panels onto the ground beneath the panels where the surface remains permeable, and therefore the total surface area of the proposed solar photovoltaic panel array is not considered to act as an impermeable area. This is confirmed by the EA which has previously stated, with regard to a similar proposed solar farm site, that *"We accept the premise that surface water volumes are unlikely to be exacerbated by the proposed development since the overall impermeable area will not be significantly altered"*.

A study of the hydrological implications of solar farms (Cook, L.M. and McCuen, R.H. (2013) 'Hydrologic Response of Solar Farms', Journal of Hydrologic Engineering, 18: 536 - 541) confirmed that solar photovoltaic panels themselves will not have a significant effect on the surface water run-off rate, volume or time to peak from a site. The study did however identify that the nature of the underlying groundcover can have a demonstrable influence on the surface water run-off characteristics of a site, such that if the ground cover beneath panels is proposed as bare earth, peak discharges can increase significantly. It is therefore recommended that grass cover be established across the portion of the site in which solar photovoltaic panels are to be located. This practice was identified by the study as ensuring that such schemes will not increase the surface water run-off rate, volume or time to peak compared to the pre-development situation.

The proposed establishment of grassland at the site will represent a change in land cover, with the current arable land being seeded to allow the establishment of grassland that will likely be managed through either a grazing regime or manual cutting. The change in land cover will result in a more 'natural' infiltration response, such that the proposed development will mimic a favourable 'greenfield' response, in terms of reducing the surface water run-off rate, volume and time to peak compared to the pre-development situation.

It is proposed to direct rainfall run-off from the solar photovoltaic panels to discharge directly onto the surrounding ground. Rainfall will continue to preferentially infiltrate to ground, or run-off overland once the infiltration capacity of the ground has been exceeded, and into the existing surrounding ditches/watercourse, as in the existing situation.

Whilst it is accepted that there will be a concentration of run-off from the bottom edge of the panels (albeit the likelihood of this is minimised as a result of the vertical and horizontal gaps between the panels, as shown at Figure 4), any rainwater unable to infiltrate at that point will flow across the ground between the downslope proposed panel rows and infiltrate there as in the existing ‘natural’ situation (i.e. approximately the same surface area will be available for infiltration compared to the pre-development situation).



Figure 5: Photovoltaic Panel Gaps - Example

This arrangement will ensure that existing drainage patterns will not be altered, and therefore that flood risk is not increased off-site.

5.2.2 *Proposed Access Tracking and Temporary Construction Compounds*

To negate any concerns regarding soil compaction during construction and operation, which has the potential to increase surface water run-off, proposed access tracking and temporary construction compounds should be formed pre-construction using permeable materials (compacted hardcore) so as to avoid creating impermeable areas across the site, and to limit ground compaction and hence surface water run-off intensification. Any rainwater falling onto the permeable areas will preferentially infiltrate to ground, or run-off overland once the infiltration capacity of the ground has been exceeded, and into the existing surrounding ditches/watercourse, as in the existing situation. Temporary compound and access areas should be reinstated as grass following completion where they are not required for regular maintenance access.

5.2.3 *Summary*

In summary, the proposed drainage strategy utilises the existing topography and natural drainage regime to ensure that any overland flows, although not increased compared to the existing situation, will be allowed to infiltrate to ground, or run-off overland once the infiltration capacity of the ground has been exceeded, and into the existing surrounding ditches/watercourse, as in the existing situation. Assuming that grass cover and compacted hardcore surfacing will be established across the site, this will

therefore maintain or improve the existing hydrological regime, without resulting in any increased volume or intensity of run-off; alteration of catchment drainage patterns; or, unintentional creation of preferential flow paths.

On the basis of the above, the proposed development is in fact considered to result in a favourable drainage response and therefore a specific engineered drainage strategy is considered unnecessary to control the hydrological response of the site to rainfall.

6. SUMMARY

This Flood Risk Assessment (FRA) report has been prepared by Hydrock on behalf of AARDVARK EM Limited in support of a planning application for proposed solar farm development on the land of Low Farm, Flockton, Wakefield.

A detailed assessment of flood risk has identified that the site is located within Flood Zone 1 (Low Risk) in respect of fluvial flood risk, and is at 'low' or 'negligible' risk of flooding from all other potential sources.

In accordance with the NPPF and NPPG, the application of the Sequential and Exception Tests is concluded to not be required in this instance.

It is recommended that where possible, solar panels are raised a minimum of 0.8m above adjacent ground levels to address any residual risk of surface water flooding on the site.

The proposed drainage strategy utilises the existing topography and natural drainage regime to ensure that any overland flows, although not increased compared to the existing situation, will be allowed to infiltrate to ground, or run-off overland once the infiltration capacity of the ground has been exceeded, and into the existing surrounding ditches/watercourse, as in the existing situation. Assuming that grass cover and compacted hardcore surfacing will be established across the site, this will therefore maintain or improve the existing hydrological regime, without resulting in any increased volume or intensity of run-off; alteration of catchment drainage patterns; or, unintentional creation of preferential flow paths.

It has also been demonstrated that a means of safe access and egress is possible to and from the site via existing entrances or farm access roads off the A642 and Grange Lane and that the proposed development is also not considered to increase flood risk within the catchment through a loss of floodplain storage.

This report therefore demonstrates that, in respect of flood risk, the proposed development of the site:

- Is suitable in the location proposed.
- Will be adequately flood resistant and resilient.
- Will not place additional persons at risk of flooding, and will offer a safe means of access and egress.
- Will not increase flood risk elsewhere as a result of the proposed development through the loss of floodplain storage or impedance of flood flows.
- Will put in place measures to ensure surface water is appropriately managed.

As such, the application is concluded to meet the flood risk requirements of the NPPF.

Hydrock Consultants Limited

7. REFERENCES

References			
	Author	Date	Description
A	JBA	July 2016	Calder Catchment Strategic Flood Risk Assessment – Volume II (Kirklees Council) (https://www.kirklees.gov.uk/beta/planning-policy/pdf/flood-risk/strategic-flood-risk-assessment-2.pdf)