



PROPOSED SOLAR PARK, LAND TO THE WEST OF DELPH ROAD

DRAINAGE STRATEGY AND FLOOD CONSEQUENCES ASSESSMENT

LIGHTSOURCE RENEWABLE ENERGY

FEBRUARY 2015



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1. INTRODUCTION

- 1.1. This Drainage Strategy has been prepared on behalf of Lightsource Renewable Energy in connection with proposals for the development of a Solar Photovoltaic (PV) Park which could produce up to 5MW of power on land to the west of Delph Road, Penycae, Wrexham.
- 1.2. The site is situated south of Stryt-Issa, north of Rhosymedre. The extent of the site is shown on **Figure 1** below. The site extends to approximately 10.7 hectares in area. The existing use comprises agricultural land and is bound by hedgerows and lanes.

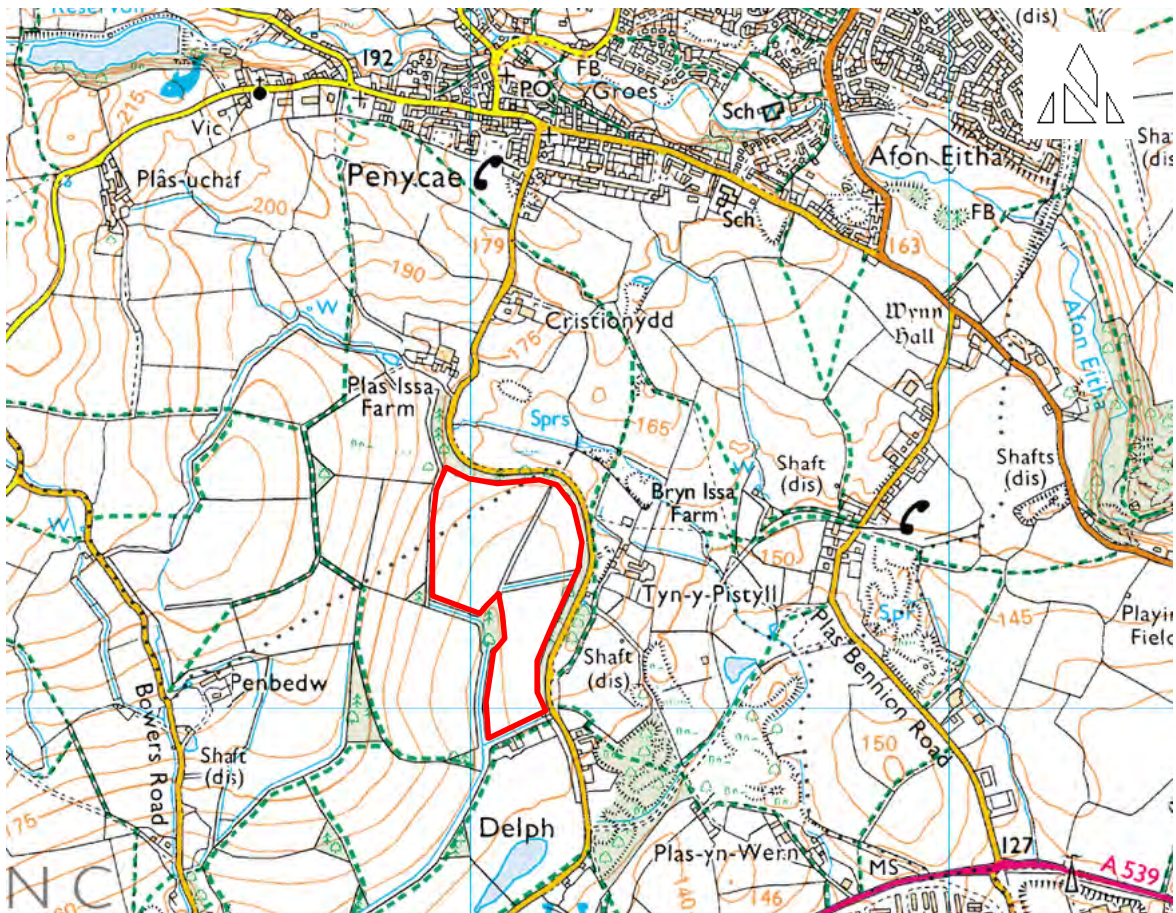


Figure 1: Site Location Plan

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- 1.3. The development proposals comprise the construction of a solar park consisting of photovoltaic modules mounted on metal frames, with associated site infrastructure and ancillary control equipment. A Site Layout is reproduced in **Appendix 1**.

The main purpose of this site-specific Drainage Strategy and Flood Consequences Assessment is to provide sufficient flood risk information to support a planning application for the development proposals and to demonstrate that the development would be appropriately safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where practicable, would reduce flood risk overall.

2. SCOPE OF THE ASSESSMENT

National Planning Policy

- 2.1. Planning Policy Wales (PPW) 6th Edition was published by the Welsh Government in February 2014 and provides an overview of the planning system in Wales. It identifies that flood risk is a material consideration in land use planning. Paragraph 13.4.2 states that Local Planning Authorities should ensure that development does not:
- Increase the risk of flooding elsewhere by loss of flood storage or flood flow route; or
 - Increase the problem of surface water runoff.
- 2.2. PPW is supplemented by a series of Technical Advice Notes. Technical Advice Note 15 (TAN15): Development and Flood Risk, published in July 2004, sets out the Welsh Assembly Government's policy on development and flood risk.
- 2.3. TAN 15 sets out a precautionary framework to guide planning decisions for new development in areas at high risk of flooding with the aim to direct new development away from those areas which are at high risk of flooding. Paragraph 7.2 of TAN 15 states that whether a development should proceed or not will depend upon whether the consequences of flooding of that development can be managed down to a level which is acceptable for the nature/type of development being proposed, including its effects on existing development. Appendix 1 of TAN 15 provides guidance on the technical requirements for undertaking an assessment of the potential consequences of a flooding event.
- 2.4. TAN15 categorises Wales into three Zones (A, B and C) based on their risk of flooding. The Welsh Government (WAG) published its Development Advice Map (DAM) based on the best available information considered sufficient to determine when flood risk issues need to be taken into account in planning future development. The maps are based on the Environment Agency's extreme flood outlines (Zone C) and the British Geological Survey drift data (Zone B). An extract from the Welsh Government DAM obtained from its website, which shows the Flood Zones in the vicinity of the site, is reproduced as **Figure 2** below. The application site lies wholly within Flood Zone A. Figure 1 within TAN15 states that Flood Zone A is considered to be at little or no risk of fluvial or tidal/coastal flooding. The justification test is not applicable for development in Zone A. Development in Zone A still needs to refer to surface water requirements and the acceptability criteria will only be passed if the development will not increase flooding elsewhere.

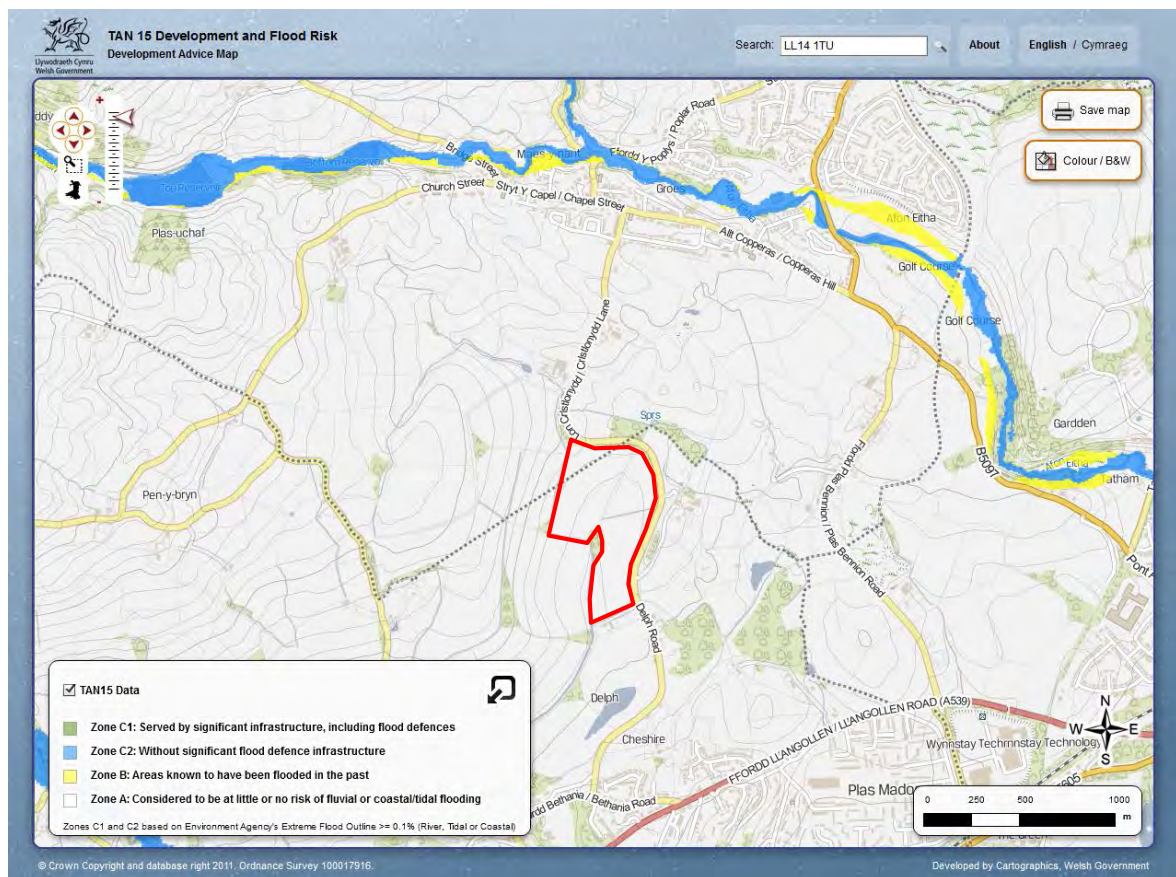


Figure 2: Welsh Government's Development Advice Map (DAM)

- 2.5. TAN 15 recognises the need for the assessment of the source of potential flooding from rivers, tidal flooding, coastal flooding, groundwater, surface water or any combination of these.
- 2.6. The Welsh Government has advised that a Flood Consequences Assessment is not required if a site lies entirely within Flood Zone A. However, for major developments (*i.e. greater than 1 hectare*), where drainage implications can be significant, it suggests that a "Drainage Strategy" Report be prepared to support the application.
- 2.7. Paragraph 8.3 in TAN 15 specifically states that development should not increase the risk of flooding elsewhere and that the aim of new development should be to not create additional run-off when compared with the undeveloped situation.
- 2.8. Due to the size and nature of the proposed development it is prudent to assess flood risk posed to the application site and propose a Drainage Strategy to mitigate any potential increase in the flood risk to others. Paragraph A1.17 contained in Appendix 1 of TAN 15 notes that the detail and technical complexity of an assessment of flood consequences will reflect the scale and potential significance of the development.

Local Planning Policy

- 2.9. The Wrexham Unitary Development Plan 1996-2011, adopted February 2005, is the most up to date Plan for the purposes of making planning decisions except where there have been significant changes to national planning policy which have overtaken parts of the UDP, making those policies obsolete or no longer relevant. Policies relevant to the proposed development include Strategic Policy PS2, General Development Principle Policy GDP1, EC13 – Surface Water Run-off, and EC14 – Protection of Controlled Waters.
- 2.10. Policy PS2 states:-
“Development must not materially detrimentally affect countryside, landscape/townscape character, open space, or the quality of the natural environment.”
- 2.11. Policy GDP1 states:-
“All new development should:-
i) Ensure that development does not result in, or is subject to, flooding, soil erosion, landslides or contamination, either on or off the site.”
- 2.12. Policy EC13 states:-
“Development which would result in an unacceptable adverse impact on the water environment due to additional surface water run-off will not be permitted.”
- 2.13. Policy EC14 states:-
“Development which would have an unacceptable adverse impact upon the capacity, flow, quality or availability of controlled waters and associated land will not be permitted.”
- 2.14. The scope of this Drainage Strategy is therefore to provide sufficient information to satisfy the relevant requirements of PPW, TAN 15 and local planning policy.

3. DRAINAGE STRATEGY

Site Description and Hydrological Context

- 3.1. The Ordnance Survey map of the area shows geographical features including watercourses and other bodies of water.
- 3.2. Drainage ditches are located within the site boundaries; these are classified as 'ordinary watercourses'. The location of these features is shown on the topographical survey, reproduced in **Appendix 2**.

Site Levels

- 3.3. The site slopes from a high point of approximately 171m AOD in the north-west of the site, to around 154m AOD in the southern corner of the application area. A copy of the Topographical Survey, MK Surveys' drawing number 20444-1, is reproduced in **Appendix 2**.
- 3.4. The northern half of the site slopes in a southerly direction at a gradient of approximately 1:15 towards the drainage ditches located within the site. The southern part of the site slopes from east to west at a gradient of around 1:30.
- 3.5. The potential existing overland flow routes have been identified based on the site's topography. These are marked on drawing number L335/4 Rev A, a copy of which is contained in **Appendix 3**.

Ground Conditions

- 3.6. The British Geological Survey® NERC (2014) online geological mapping indicates that the application site is underlain by Pennine Lower Coal Measure Formation and Pennine Middle Coal Measures Formation (undifferentiated).
- 3.7. From an inspection of the Environment Agency's Aquifer Designation Map on its website the site is underlain by a 'Secondary A' Aquifer which is classified as permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. A copy of the Environment Agency's Aquifer Designation Map is reproduced in **Figure 3** below.

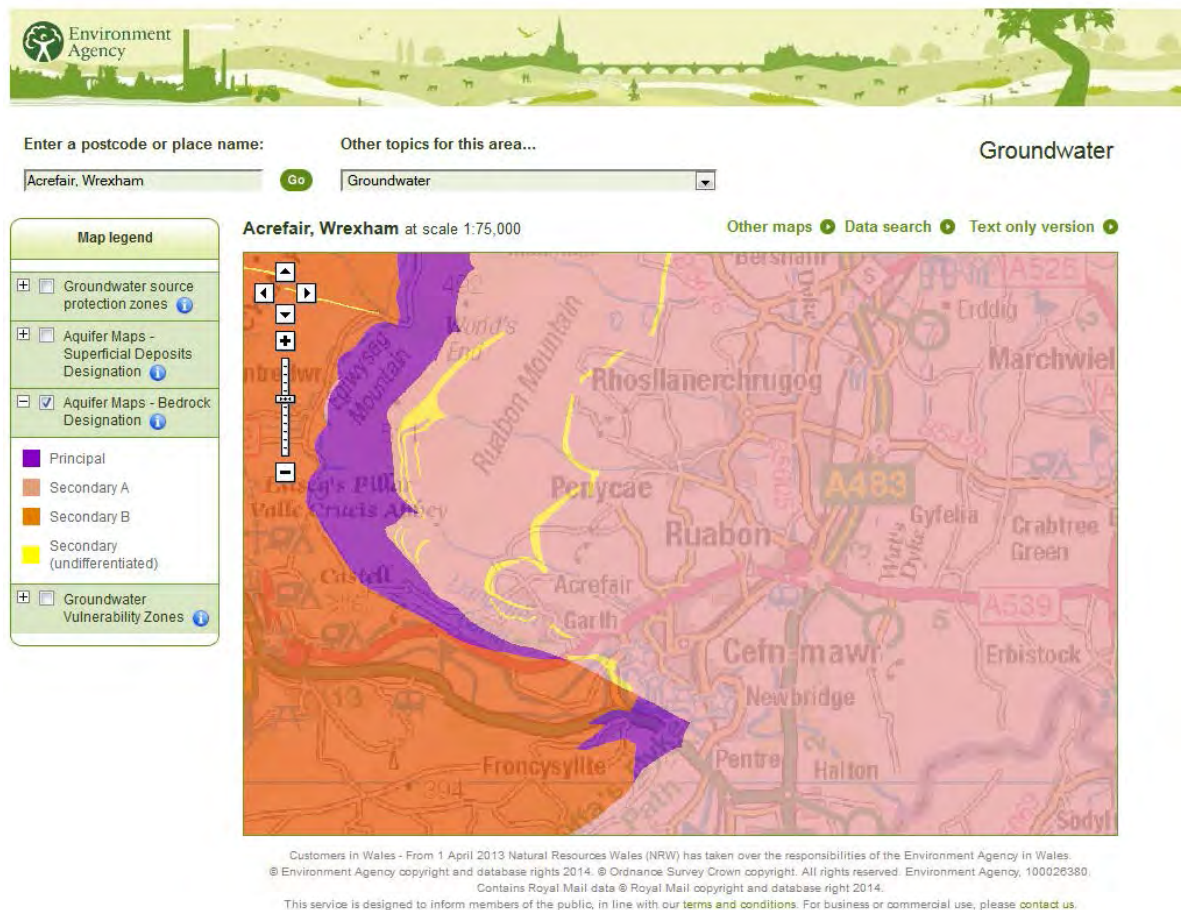


Figure 3: Environment Agency's Aquifer Designation Map

- 3.8. From an inspection of the Environment Agency's Groundwater Source Protection Zone Map the site does not lie within a Groundwater Source Protection Zone.
- 3.9. Based on the Flood Studies Report (FSR) Winter Rainfall Acceptance Potential (WRAP) Map, as shown on Drawing Number L335/5 Rev A reproduced in **Appendix 4**, the site is located in a 'Soil Index Class 2' area. Soil Index Class 2 has a relatively high Winter Rainfall Acceptance Potential and low standard percentage runoff, and so suggests the underlying soil has relatively good permeability.

Definition of the Flood Hazard and Probability

Sources of Information

- 3.10. Wrexham County Borough Council (CBC) Local Flood Risk Management Strategy (LFRMS) was published in April 2013. This sets out Wrexham CBC's principles, objectives and measures for the management of local flood risk. Local flood risk is defined as "surface water run off, ground water and ordinary watercourses and included any lake, pond or other body of water that feeds from an ordinary watercourse".
- 3.11. The River Dee Catchment Flood Management Plan splits the Dee catchment into 10 distinct sub-areas which have similar physical characteristics. The site is located in the Main Alyn (Policy Option 3) sub-area. Policy 3 states:-

“Policy Option 3 – areas of low to moderate flood risk where we are generally managing existing flood risk effectively.”

- 3.12. The Environment Agency’s interactive Flood Hazard Maps, published on its website, show the risk of flooding from rivers and sea, from reservoirs, and from surface water, and indicate the extent, depth and velocity of water for a number of scenarios. These are not suitable for land-use planning and the Flood Map for Planning and Development Advice Map needs to be used for this purpose. Nonetheless these Flood Hazard Maps contain information which needs to be taken into account as part of a Drainage Strategy.
- 3.13. On 1 April 2013 Natural Resources Wales took over the work of the Environment Agency Wales. However, in the interim period the majority of the modelling procedures and flood risk data are still listed on the Environment Agency’s website. In the absence of specific guidance for developments in Wales, Environment Agency information has been referenced throughout this report.

Flooding from Watercourses

- 3.14. The DAM reproduced in Figure 2 shows the site as entirely within Flood Zone A. Figure 1 in TAN15 states that Flood Zone A has little or no risk of fluvial or tidal / coastal flooding.
- 3.15. The Environment Agency’s Flood Map for Planning (Rivers and Sea) obtained from its website, showing the Flood Zones in the vicinity of the site, identifies that the site lies entirely within Flood Zone 1. This is defined as the zone with the lowest probability of flooding from rivers and the sea. It should be noted that the Environment Agency’s flood map is continually being updated and therefore the extent of the extreme flood outline will differ from the published DAM. Whichever mapping is utilised there can be no question that the site lies within an area with very low risk of flooding from rivers and sea.

Flooding from Surface Water

- 3.16. The Environment Agency’s Risk of Flooding from Surface Water Map indicates where surface water may be expected to flood or pond. Surface water flooding happens when rainwater does not drain away through normal drainage system or soak into the ground, but lies on or flows over the ground instead. A copy of the Environment Agency’s Risk of Flooding from Surface Water Map is reproduced in **Figure 4** below.

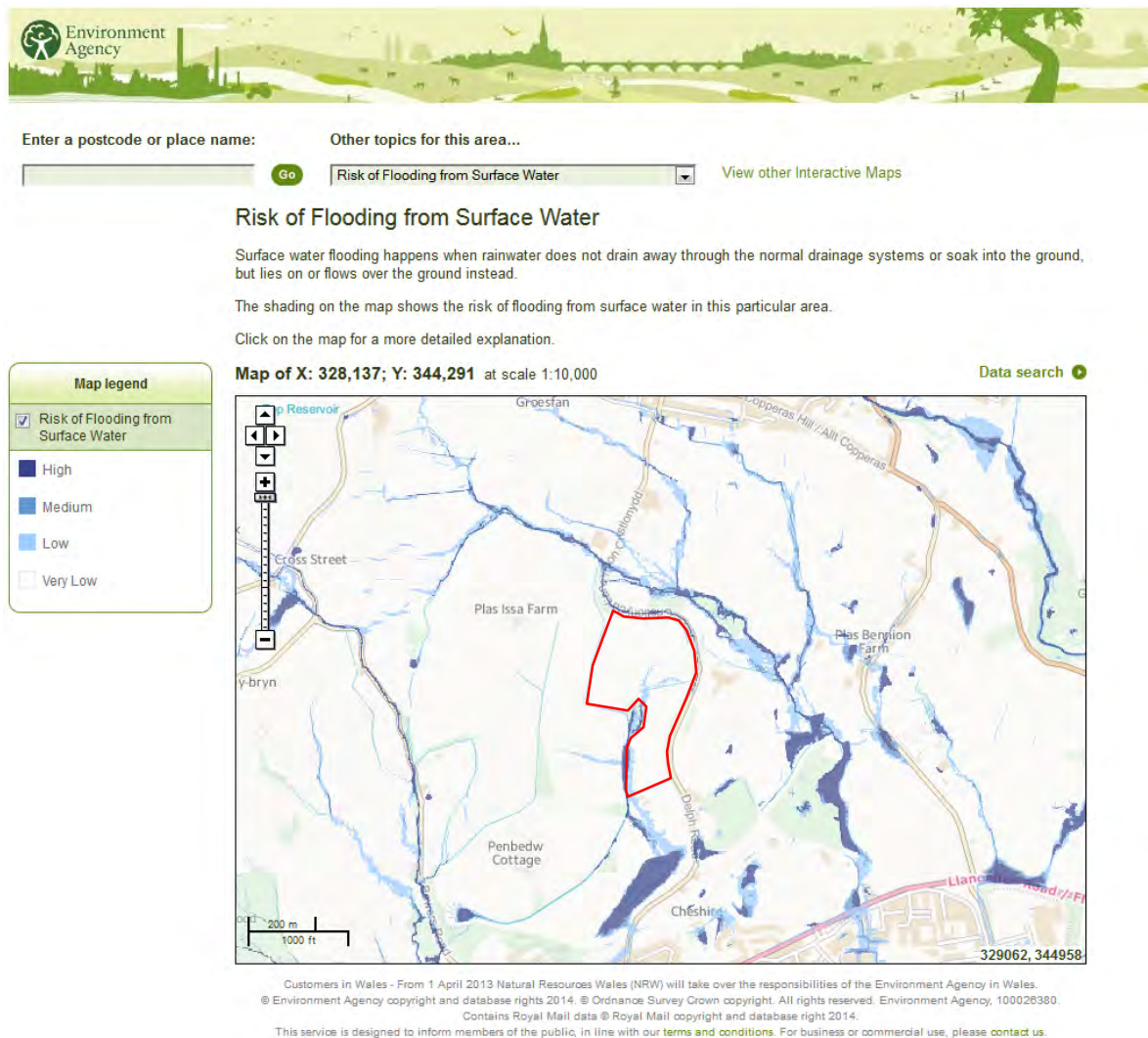


Figure 4: Environment Agency Risk of Flooding from Surface Water Map

- 3.17. The Risk of Flooding from Surface Water Map shows that, as would be expected, the watercourses within the site lie in an areas with a High (> 1 in 30) chance of surface water flooding. The associated Surface Water Depth and Surface Water Velocity Maps, indicate that for a Medium chance of occurring (up to 1 in 100) the area would have surface water flooding to a depth of 300 -900mm with a velocity of less than 0.25 m/s.

Flooding from Other Sources

- 3.18. The LFRMS does not identify any incident of flooding from overwhelmed sewers and drainage systems affecting the site.
- 3.19. The Environment Agency's Risk of Flooding from Reservoirs Map indicates the site is not at risk of flooding from reservoir breaching.
- 3.20. The PFRA identified no records of past groundwater flooding within the County Borough.
- 3.21. A summary of the potential risk from all sources of flooding associated with existing conditions pre-development is shown in **Table A** below.

Table A: Pre-development Potential Flood Risk from All Sources of Flooding

Flood Source	Potential Risk				Description
	None	Low	Medium	High	
Watercourses		X			The site is located in Flood Zone A.
Surface Water		X			The topography of the land indicates that any overland flow would be directed into the ditch network away from the site.
Groundwater		X			No risk of groundwater flooding is identified.
Overwhelmed Sewers		X			No incidents of sewer flooding affecting the site are identified.
Artificial Sources	X				None identified.

- 3.22. The pre-development potential flood risk to the site from all sources of flooding is considered to be low. It is therefore considered that the most likely cause of potential flooding affecting the 'greenfield' site would be extreme rainfall falling on the sub-catchment area exceeding the soil's natural infiltration rate or capacity, leading to an increase in the volume and rate of runoff and resulting in overland flood flows and ponding at localised low spots.

The Development Proposals

- 3.23. The development proposals comprise the construction of a Solar Park consisting of photovoltaic (PV) modules mounted on metal frames (known as arrays), with associated site infrastructure and ancillary control equipment. A Site Layout is reproduced in Appendix 1.
- 3.24. The frames have a minimal cross-sectional area and will be 'pile driven' or 'screw anchored' into the ground. The proposed development does not involve any change in ground levels. The array of panels will be situated in rows running from east to west, south facing inclined at an angle of approximately 20 degrees from the horizontal, with an approximate 3.5m separation between lines of panels. Each frame contains four rows of PV panels separated by a horizontal 'rainwater' gap. This gap allows rainwater to drain freely to the ground beneath and between the PV panels, replicating the existing greenfield scenario. The lower edge of the panels will be a minimum of 0.8m above ground level, allowing grass to grow underneath the panels. **Figure 5** shows a typical cross section of a Solar Array.

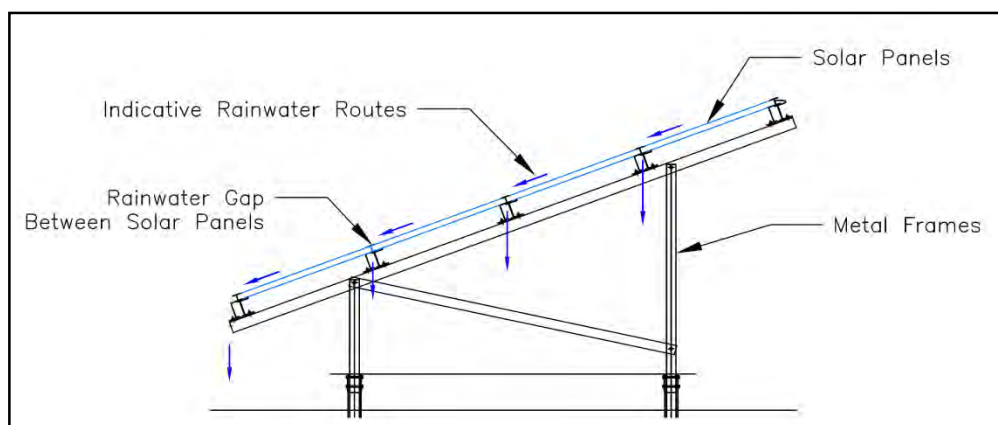


Figure 5 – Typical Solar Array Cross Section

Note: Based on four PV panels per frame.

- 3.25. Any access tracks will be formed using permeable materials (open graded stone or reinforced grass) so as to avoid creating impermeable areas across the site.

- 3.26. Ancillary equipment will be contained in small buildings, typically Glass Reinforced Plastic (GRP) kiosks. Ancillary equipment includes Inverter Cabinets which contain an Inverter, Transformers and associated switch gear; a separate Control Room; and a Sub-substation. Due to their small size it is proposed that roof water from these buildings will discharge directly onto the surrounding ground. Minimum floor levels for buildings on the site would be set at least 150mm above ground level to prevent the ingress of water.
- 3.27. BRE published its '*Biodiversity Guidance for Solar Developments*' in 2014. The report recognises that in most solar farms "*normally only 25-40% of the surface is over-sailed by panels*" and "*because panels are raised above the ground on posts greater than 95% of a field utilised for solar farm development is still accessible for plant growth ...*" ¹. Subsequently, the majority of the site will remain as "soft" surface, with grassland around and underneath the photovoltaic panels.
- 3.28. Natural England's '*Technical Information Note TIN101: Solar Parks: Maximising Environmental Benefits*' states:
- "The key to avoiding increased run-off and 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."*
- 3.29. **Figure 6** shows a typical scene from an operational Solar Park with vegetation cover between and under the solar arrays which will delay surface water runoff and prevent soil erosion.



Figure 6 – A Typical Operational Solar Park

- 3.30. Soil compaction will be limited during construction and operation of the Solar Park. During construction only light machinery will be required to install the solar array and vehicle movements will be minimised. Low ground pressure vehicles are recommended during wet weather working. Any HGVs will be restricted to a temporary construction compound by the site's entrance.

¹ BRE (2014) Biodiversity Guidance for Solar Development. Eds G E Parker and L Greene.

- 3.31. If necessary, to alleviate the effects of any compaction during the construction process, any affected areas will be harrowed and seeded prior to final commissioning of the Solar Park.
- 3.32. During operation of the Solar Park maintenance of the panels will be infrequent, minimal and will only require light machinery. Thus, the infiltration rate of the underlying ground is unlikely to be changed by the proposed development.
- 3.33. During the operation of the Solar Park the areas under and around the solar array will be suitable for grazing by livestock, typically sheep.
- 3.34. At present the proposed development site is likely to be used for arable agriculture which requires the periodic ploughing of the site. Exposed soil is at a greater risk of erosion compared with a field with covering vegetation and can result in greater runoff. Upon completion of the Solar Park the site will be permanently grassed thereby reducing the risk of soil erosion and reducing potential runoff compared with the existing condition.

Greenfield Runoff

- 3.35. The proposed development will have a very limited extent of impermeable ground cover. The area beneath the solar panels will remain grassed and the post development site infiltration rate will not change. Rainwater falling onto each panel will drain freely onto the ground beneath the panel and infiltrate into the ground at the same rate as it does in the site's existing greenfield state as indicated in TIN101². Thus, the total surface area of the photovoltaic array will not be considered an impermeable area in this assessment (only the area taken up by the panel supports). Similarly, it can be assumed that any rainwater falling onto the permeable access tracks will soak into the ground beneath or adjacent to the tracks at the same rate that it presently does.
- 3.36. The extent of impermeable area created as a result of the proposed Solar Park is summarised in **Table B**.

² Natural England (2011) Technical Information Note TIN101: Solar parks: maximising environmental benefits.

Table B: Created Impermeable Areas

	Quantity	Unit Area (m ²)	Total Area (m ²)
Piles	2376	0.01	23.76
Inverter Kiosk	3	6.72	20.16
Transformer Kiosk	2	15.00	30.00
Client Side Substation	1	14.79	14.79
Communications Building	1	10.80	10.80
Storage Shed	1	7.50	7.50
Site Transformer (Aux)	1	15.50	15.50
Toilet	1	2.86	2.86
Total Impermeable Area			125.37
Site Area			106,753
Total Impermeable Area = 0.12% of Total Site Area			

3.37. In its current greenfield state the application area is considered to be 100% undeveloped. As a result of the development of the Solar Park the extent of impermeable area will be approximately 125m² or 0.12% of the total site area.

3.38. The Environment Agency's report *Rainfall Runoff Management for Developments* [Report – SC030219] published in October 2013 provides advice on the management of stormwater drainage for developments including the calculation of greenfield runoff. The report states:

“The Environment Agency will normally require that, for the range of annual flow rate probabilities, up to and including the 1% annual probability (1 in 100 year event) the developed rate of runoff into a watercourse should be no greater than the undeveloped rate of runoff for the same event based on the calculation of Q_{BAR} or Q_{MED} and the use of FSSR growth curves.”

3.39. Table 1 of that Report states that for developments between 0 - 50 hectares the Institute of Hydrology (IH) Report 124 Flood Estimation for Small Catchments (1994) method can be used to estimate the greenfield site flow rate, Q_{BAR} (the Mean Annual Flood). Where developments are smaller than 50 ha, the analysis for determining the greenfield index flood flow rate should use 50ha in the formula and linearly interpolate the flow rate value based on the ratio of the development area.

3.40. The ICP SuDS Method contained with XP Solutions' Micro Drainage software system (Version 2014.1) calculates Q_{BAR} based on the IH124 methodology with pro-rata values for sites smaller than 50ha.

3.41. The FSR WRAP Map, shown in Appendix 4, indicates the site is located in 'Soil Index Class 2', and a Soil Index value of 0.30 has been used to calculate Q_{BAR} using the ICP SuDS Method.

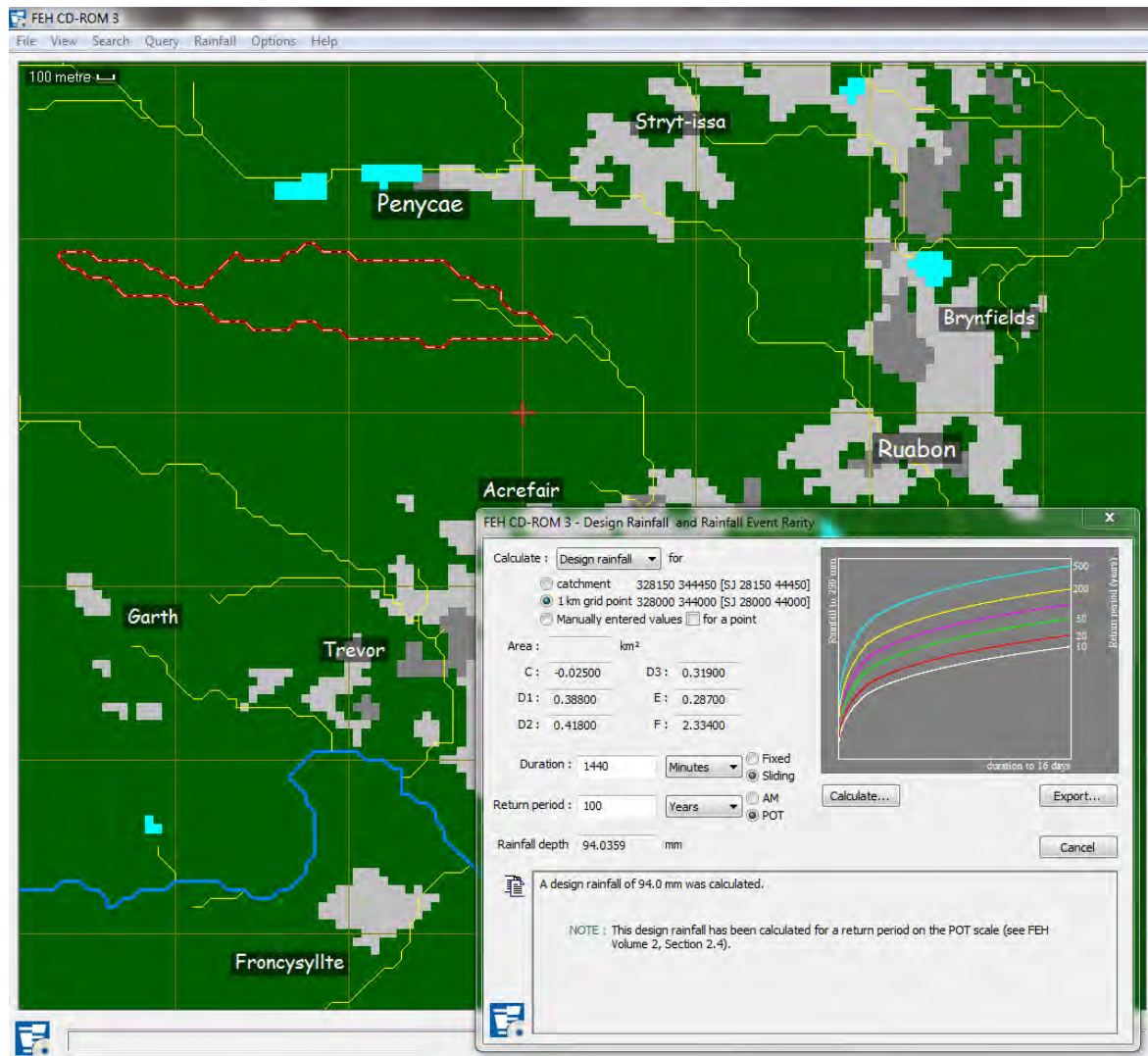
- 3.42. Q_{BAR} has been calculated for the site in both an undeveloped and post development site. Copies of the MicroDrainage greenfield runoff calculations are included in **Appendix 5**. A summary of the pre and post development greenfield runoff rates for the various return period events is shown in **Table C**. The mean annual peak rate of runoff, referred to as Q_{BAR} in ICP SuDS Method, for the pre-development greenfield site is 29.5 l/s. Whereas the post development site Q_{BAR} is calculated as 29.6 l/s.

Table C: Greenfield Runoff Rates

Return Period (Years)	1	Q_{BAR}^a	30	100
Greenfield Runoff Rates (l/s)	26.0	29.5	52.1	64.4
Post Development Unmitigated Runoff Rate (l/s)	26.0	29.6	52.1	64.5

^a Q_{BAR} = Mean Annual Flood with an approximate return period of 2.3 years.

- 3.43. The calculations contained in Appendix 5 quantify the effect of the proposed Solar Park on greenfield runoff rates. These calculations show that the effect of the Solar Park on Q_{BAR} is negligible and only equates to an increase of 0.1 l/s or 0.3% of the greenfield runoff rate.
- 3.44. New developments are required to take account of the impacts of climate change. The allowances to be made for climate change effects when assessing flood risk are related to the lifetime of the development. The 'life' of the development is identified as 30-35 years. With reference to Table 2 of the Environment Agency's guidance entitled '*Climate change allowance for planners*', dated September 2013, the appropriate allowance for climate change is to increase the peak rainfall intensity for the 1 in 100 year storm event by 10%, as a worst case scenario.
- 3.45. The Depth-Duration-Frequency (DDF) Model function was used in the Flood Estimation Handbook (FEH) CD-ROM to calculate the depth of rainfall from a 24 hour (or 1440 minutes), 100 year storm event at the application site. The results of this calculation are shown on **Figure 7**. Thus, the 1440 minute, 100 year plus climate change design rainfall for the application site is 94.0mm x 1.1 = 103.4mm (or 0.103m). The total extent of impermeable area created as a result of the proposed development is 125m². The volume of runoff generated by this rainfall event falling on 125m² impermeable area calculated by this method equates to 12.9m³ (0.103m x 125m²).
- 3.46. On this basis, the additional runoff generated in the extreme 1440 minute duration, 1 in 100 year storm event, including an allowance for climate change, would amount to approximately 12.9 m³.



Proposed Surface Water Management Measures

- 3.50. A sustainable drainage strategy, involving the implementation of SuDS, is proposed for managing the disposal of surface water runoff from the proposed development on the site.
- 3.51. Natural England's '*Technical Information Note TIN101: Solar Parks: Maximising Environmental Benefits*' encourages existing land drainage to be maintained. Existing onsite drainage ditches or features will therefore be retained in their existing state, and will continue to intercept overland flows from the site.
- 3.52. Whilst it is considered that the photovoltaic panels will not result in a material increase in surface water run-off flow rates, it is proposed to provide a SuDS arrangement by way of swales in the lower areas of the site to intercept extreme flows which may already run offsite. It is emphasised that the swales do not form part of a formal drainage scheme for the development but are provided as a form of 'betterment'. A plan of the proposed drainage arrangements, showing the proposed swale locations which are situated having regard to overland flow routes, is included as **Appendix 6**.
- 3.53. Swales will be constructed along the site boundary as series of discrete 'stepped' units parallel to the site's contours to ensure flows are not concentrated or conveyed downhill.
- 3.54. The proposed swales will have a minimum depth of 300mm, with 1 in 3 side slopes, and a base width of 0.5m. The swales provide a total storage volume of approximately 37m³. This is greater than the volume of additional runoff generated as a result of the 1440 minute, 100 year plus climate change rainfall event (12.9m³). It is therefore considered that the swales would adequately mitigate any increase in runoff volume generated as a result of the minor increase in impermeable area.
- 3.55. Swales will be sown with the appropriate seed mix upon construction and vegetation will be maintained by the landowner thereafter for the life of the proposed development.
- 3.56. The swales will be located outside of any Root Protection Zones, will not be located closer than 8m to any Main Rivers or within 5m of any ordinary watercourses or drainage ditches and will respect natural topography in accordance with local bye-laws.
- 3.57. The provision of swales has a minor benefit in reducing overland flows during extreme rainfall events. On this basis the proposed development would not increase flood risk onsite or elsewhere and would preserve the application site's natural drainage regime.

Swale Construction and Maintenance

- 3.58. The swales will be constructed before construction of the solar array commences and planted with covering vegetation to protect against soil erosion. The swales will be maintained throughout the design life of the development by the land owner/ tenant generally in accordance with the recommendations in CIRIA C697 '*The SuDS Manual*'. The proposed maintenance procedures are set out in **Table D**.

Table D: Swale Maintenance Procedures

Maintenance Schedule	Required Action	Frequency
Regular Maintenance	Litter and debris removal.	As required.
	Grass cutting or animal grazing – to retain grass height to site owner's specification.	As required.
	Manage other vegetation and remove nuisance plants.	Monthly (as stated, then as required)
Occasional Maintenance	Check for poor vegetation growth due to lack of sunlight or dropping of leaf litter, and cut back adjacent vegetation where possible.	Annually
	Re-seed areas of poor vegetation growth. Alter plant types to better suit conditions, if required.	Annually, or if bare soil is exposed over 10% or more of the swale treatment area.
Remedial Actions	Repair erosion or other damage by re-turfing or reseeded.	As required.
	Re-level uneven surfaces and reinstate design levels.	As required.
	Scarify and spike topsoil layer to improve infiltration performance, break up silt deposits and prevent compaction of the soil surface.	As required.
	Remove build-up of sediment on upstream gravel trench, flow spreader or at top of filter strip.	As required.
Monitoring	Inspect infiltration surfaces for ponding, compaction, and silt accumulation. Record areas where water is ponding for > 48 hours.	Monthly, or when required.
	Inspect surface for silt accumulation. Establish appropriate silt removal frequencies.	Half yearly.

- 3.59. Elsewhere the Environment Agency has recommended the use of a single check sheet to ensure that any drainage issues are picked up at an early stage. Accordingly, a check sheet in the format suggested by the Environment Agency is reproduced in **Appendix 7**.

Off Site Impacts and Residual Risk

- 3.60. Residual risks are those remaining after applying the sequential approach to the location of development and taking mitigating actions.
- 3.61. For extreme events the site's topography will convey exceedance flows overland towards the low points as it would in the site's greenfield state. Flow will be intercepted by existing drainage ditches (as in the greenfield state) and as a result of the development by the proposed swales in the lower portion of the application site. It is therefore considered that the proposed development would have adequate flood protection for extreme events over the lifetime of the development and by the provision of the swale promotes a minor benefit in intercepting overland flows.
- 3.62. Safe access and egress to and from the development is a route that is safe for use without the intervention of the emergency services or others. As the site is located within Flood Zone A it is considered construction staff and occasional maintenance staff can access the proposed development safely without having to pass through a flood risk area.
- 3.63. In line with normal building practice it is proposed that any on site buildings will have floor levels raised at least 150mm above ground level with appropriate damp proof course protection. This will ensure that the interior of any such building is kept suitably dry.

- 3.64. To protect against soil erosion topsoil and covering vegetation will, as far as practicable, be maintained across the whole site throughout the construction and operation of the Solar Park, as is the case in the site's existing greenfield state.
- 3.65. A summary of the potential risk from all sources of flooding post-development with the various development mitigation measures incorporated is shown in **Table E** below.

Table E: Post-development Potential Flood Risk from All Sources of Flooding

Flood Source	Potential Risk			Description
	Low	Medium	High	
Watercourses	X			No change compared with pre-development risk.
Surface Water	X			Overland flows intercepted by proposed swales providing a degree of betterment downstream.
Groundwater	X			No change compared with pre-development risk.
Overwhelmed Sewers	X			No change compared with pre-development risk.
Artificial Sources	X			No change compared with pre-development risk.
Off-site Impacts	X			By intercepting overland flows the proposed development would reduce flood risk overall.

- 3.66. On this basis it is considered that the proposed drainage measures can safely manage any residual risks and that the proposed drainage measures would lead to an overall reduction in flood risk. It is therefore considered that the proposed development would have adequate flood protection for extreme events over the lifetime of the development.

4. CONCLUSIONS

- 4.1. This Drainage Strategy has been prepared on behalf of Lightsource Renewable Energy Ltd in connection with proposals for the development of a Solar Photovoltaic (PV) Park which could produce up to 5MW of power on land to the west of Delph Road, Penycae, Wrexham.
- 4.2. The site is situated south of Stryt-Issa, north of Rhosymedre. The site extends to approximately 10.7 hectares in area and its existing use comprises agricultural land.
- 4.3. The development proposals comprise the construction of a Solar Park consisting of photovoltaic modules mounted on metal frames, with associated site infrastructure and ancillary control equipment.
- 4.4. With reference to the Welsh Government's Development Advice Map, the entire site falls within Flood Zone A which is considered to be at little or no risk of river flooding. Subsequently, a Flood Consequences assessment is not required. Although this report does not record any other sources of flooding which may affect the application site.
- 4.5. Rainfall falling onto the photovoltaic panels would runoff directly to the ground beneath the panels and infiltrate into the ground at the same rate as it does in the site's existing greenfield state.
- 4.6. Existing drainage features will be retained and the site will remain vegetated through construction and operation of the Solar Park to prevent soil erosion.
- 4.7. The extent of impermeable cover as a result of the Solar Park amounts to only 0.13% of the total site area. Supporting calculations demonstrate that this effect of the Solar Park on the Mean Annual Flood (Q_{BAR}) is minimal and only equates to a 0.3% increase compared with the greenfield runoff rate.
- 4.8. A sustainable drainage strategy, involving the implementation of SuDS in the form of swales, is proposed for managing the disposal of surface water runoff from the proposed development on the site. Swales are proposed at the low points of the application site to intercept extreme flows which may already run offsite. It is emphasised that the swales do not form part of a formal drainage scheme for the development but are provided as a form of 'betterment'. The volume of storage provided within the proposed swales ($37m^3$) is greater than the additional runoff generated as a result of the extreme 1 in 100 year storm event, including an allowance for climate change ($12.9m^3$).
- 4.9. It is considered that the provision of swales would lead to an overall reduction in surface water flow rates from the site and mitigate any increase in run-off due to the minor reduction in the overall permeable area of the site.
- The proposed drainage strategy would ensure that the development would therefore have a negligible impact upon site drainage and surface water arising from the developed site would mimic the surface water flows arising from the site prior to the proposed development. The natural drainage regime would be retained except in the extreme storm event when a benefit is achieved by reducing the extreme storm run-off flows.
- 4.10. The overall conclusions drawn from this Flood Risk Assessment are that future users of the development would remain appropriately safe throughout the lifetime of the proposed development, and that subject to a planning condition requiring the drainage arrangements as indicated on plan L335/6 to be implemented and maintained in accordance with the procedures set out at Table D of this FRA and a Check Sheet attached as Appendix 7, the development will not increase flood risk elsewhere and will reduce flood risk overall.

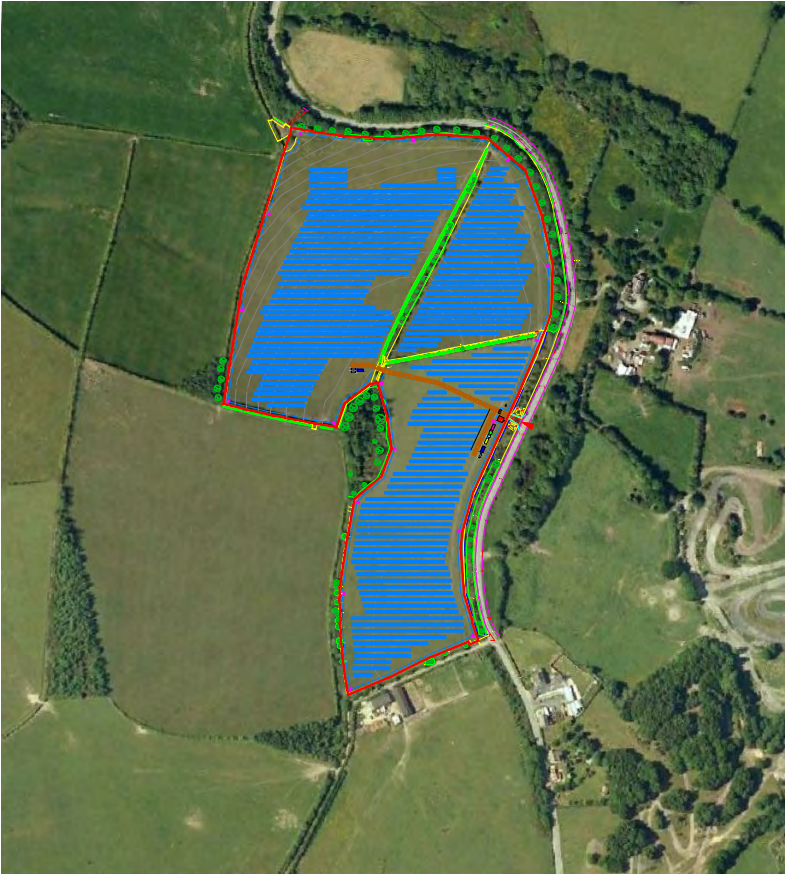
Land to the West of Delph_Proposed_Layout_Rev5

Area 106,753 m2 (26.38 acres)



	Site Boundary
	Site Access
	Security Fence
	Field Boundary
	Module Table 11 x 3
	Module Table 22 x 3
	Field Transformer
	Inverter Station
	DNO Substation
	Client Side Substation
	Communications Building
	Site Transformer (Aux)
	DNO Meter
	Storage Shed
	Access Road
	Compound Area
	Overhead Line
	Tree
	Access Gates
	CCTV
	Temporary Access Road
	WC

Scale 1:7500



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Revisions:			
5	04.02.15	Panels removed from Mine Shafts	DA
4	13.01.15	Changed to 3 landscape 25 degrees tilt	DA
3	11.12.14	Topo inserted	DA
2	26.09.14	modules relocated from S & W areas	ZA
1	25.09.14	Proposed fields changed	ZA
Rev	Date	Comments	Dwn Chkd

JK	XX	XX	27.08.14
DRAWN	CHECKED	APPROVED	DATE

PROJECT NAME & ADDRESS:
Location: Land to the West of Delph
Postcode: LL14 1TU
3° 4'32.70"W
52°59'22.92"N

NOTES:
-
-
-
-

Paper Size:	Scale:	Sheet:
A3	1:2500	1

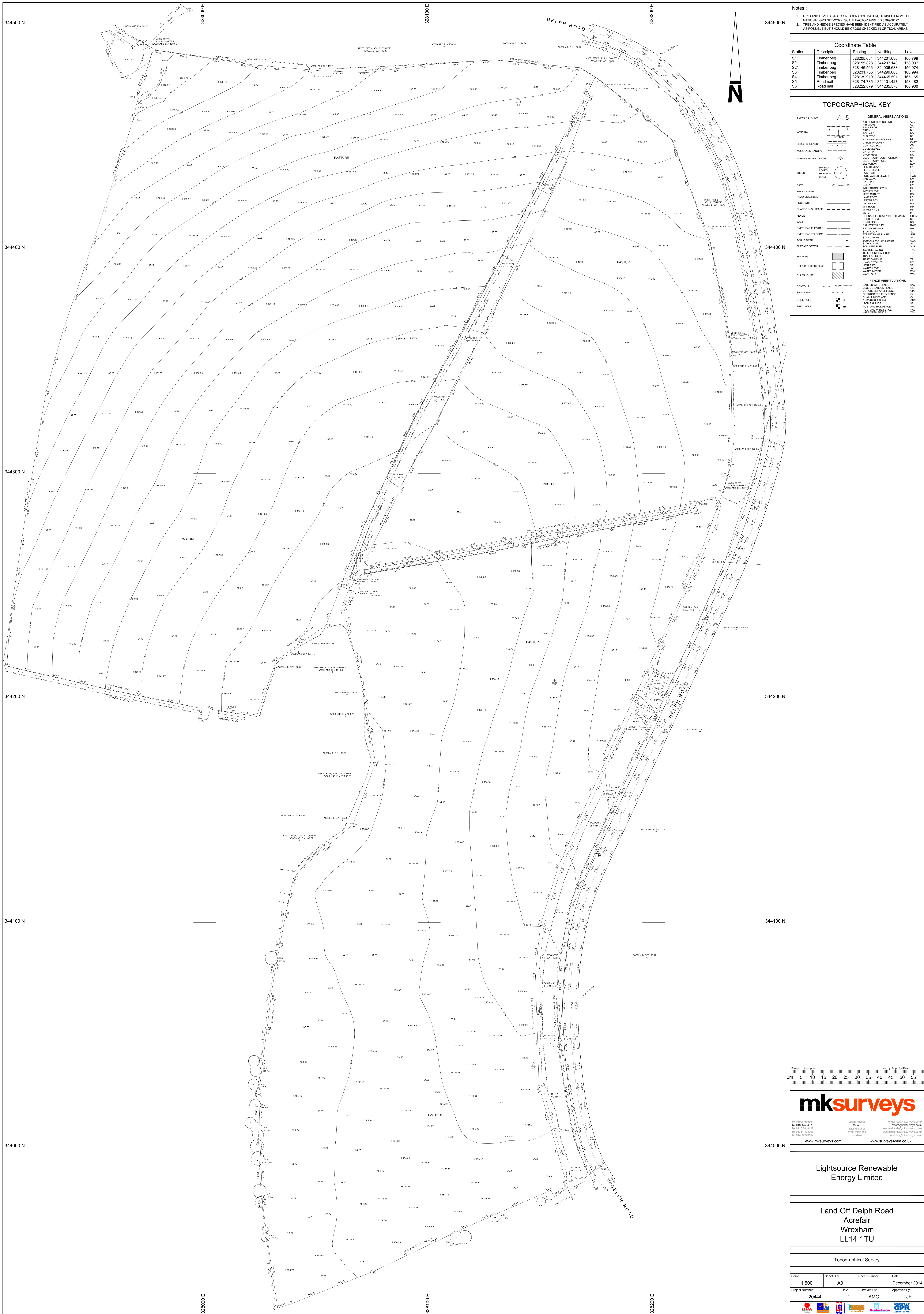
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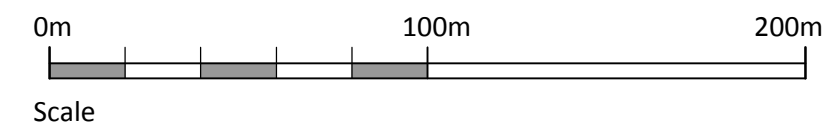
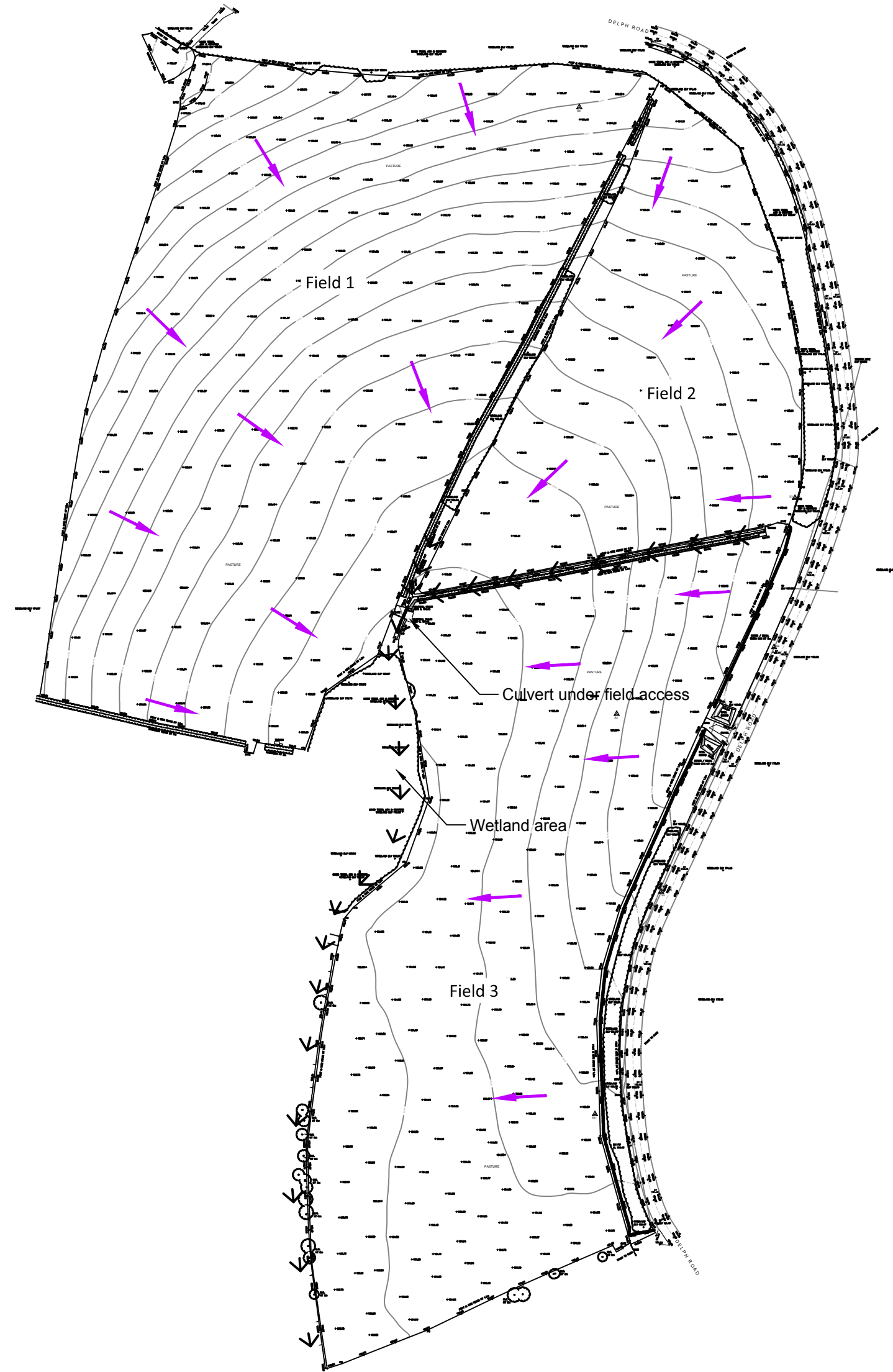
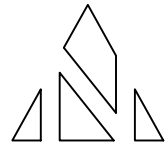
DRAWING TITLE:
Land to the West of Delph_Proposed_Layout_Rev5

DRAWING NUMBER: ACR_01_Rev5	STATUS: Preliminary
--------------------------------	------------------------

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SWITCHING ON SUNLIGHT

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Key

- ➡ Indicative Overland Flow Routes
- ← ← Direction of Flow in Ditch / Watercourse

Notes:

1. Drawing based on Topographical Survey produced by MK Surveys, Drawing Numbers 20444-1.

A	24/12/14	Project title revised	MWS
Rev	Date	Description	Initials

Client

Lightsource Renewable Energy

Project

**Proposed Solar Park,
Land West of Delph Road**

Drawing Title

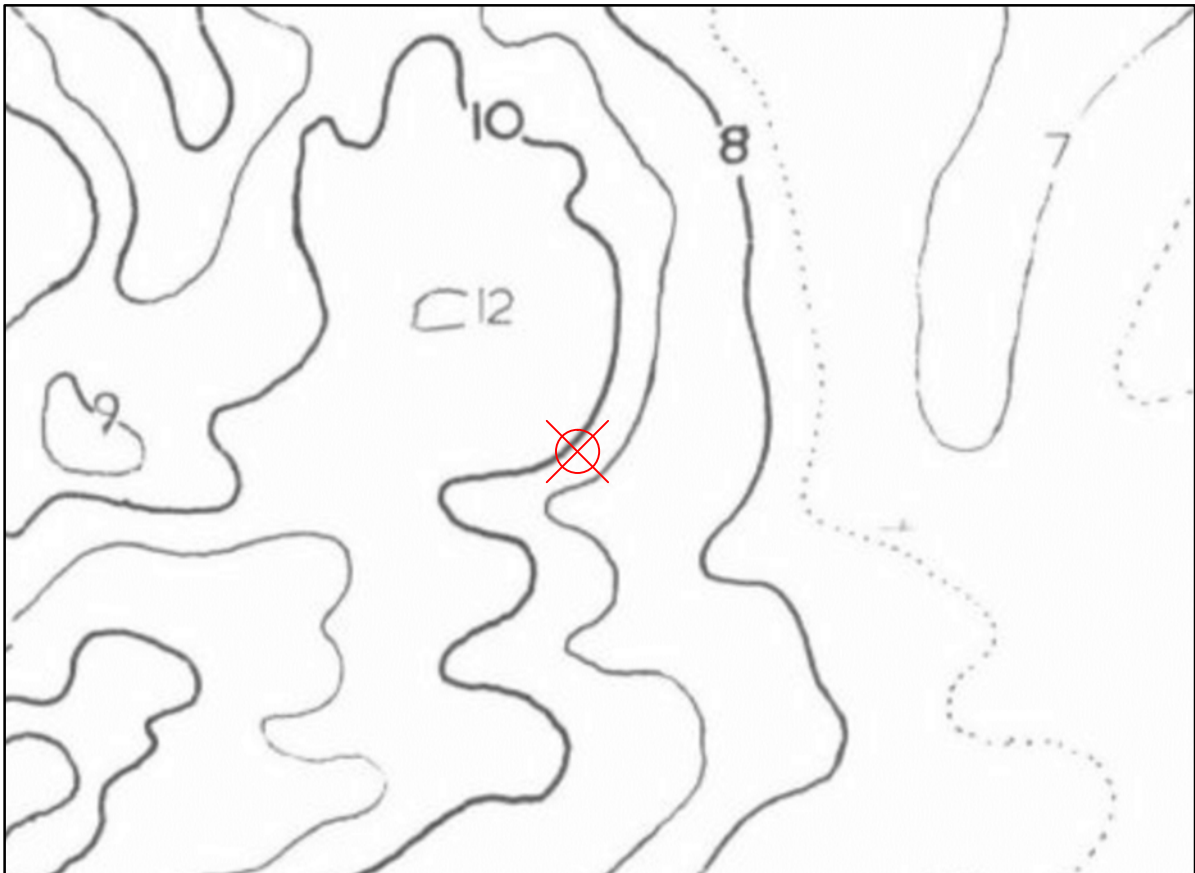
Existing Drainage Arrangements

Drawing No. **L335/4** Rev A

Date	December 2014
Scale	1:2000 @ A2
Drawn By	MWS
Checked By	GE
E-Mail	geves@pfapl.com
File Ref.	\\Drawings\L335-04.dwg



Location Plan



Standard Average Annual Rainfall (SAAR) (in hundreds of mm)



Winter Rain Acceptance Potential (WRAP)



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Telephone

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Soil Classification			
Soil Class (WRAP)	Soil Index (IoH)	SPR (FEH)	St (ADAS)
1	0.15	10	0.1
2	0.30	30	0.5
3	0.40	37	0.8
4	0.45	47	1.0
5	0.50	53	1.3

Note:
Standard Average Annual Rainfall (SAAR) and Winter Rain Acceptance Potential (WRAP) map extracts shown on this drawing are reproduced from the maps contained in Volume V of the Flood Studies Report - NERC: 1975.

A	24/12/14	Project title updated	MWS
Rev	Date	Description	Initials

Client

Lightsource Renewable Energy

Project

**Proposed Solar Farm
Land West of Delph Road**

Drawing Title

**SAAR
and
WRAP Maps**

Drawing No. **L335/5** Rev A

Date	December 2014
Scale	N.T.S. @ A3
Drawn By	MWS
Checked By	GE
E-Mail	GEves@pfapl.com
File Ref.	\\drawings\L335-05.dwg

PFA Consulting		Page 1
Stratton Park House Wanborough Road Swindon SN3 4HG		
Date 24/11/2014 15:44 File	Designed by celeste Checked by	
Causeway Source Control 2014.1		

ICP SUDS Mean Annual Flood

Input

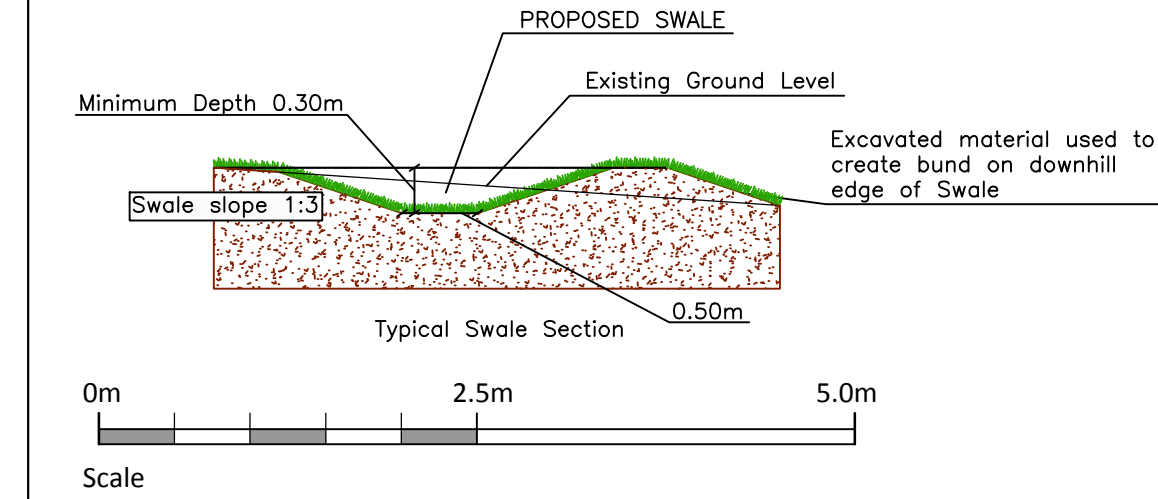
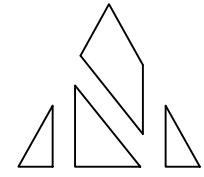
Return Period (years)	2	Soil	0.300
Area (ha)	10.675	Urban	0.000
SAAR (mm)	1000	Region Number	Region 9

Results 1/s

QBAR Rural	29.5
QBAR Urban	29.5
Q2 years	27.4
Q1 year	26.0
Q30 years	52.1
Q100 years	64.4

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PFA Consulting		Page 1
Stratton Park House Wanborough Road Swindon SN3 4HG		
Date 18/12/2014 15:35 File	Designed by MWS Checked by GE	
Causeway		
Source Control 2014.1		
<u>ICP SUDS Mean Annual Flood</u> Input Return Period (years) 2 Soil 0.300 Area (ha) 10.675 Urban 0.001 SAAR (mm) 1000 Region Number Region 9 Results 1/s QBAR Rural 29.5 QBAR Urban 29.6 Q2 years 27.5 Q1 year 26.0 Q30 years 52.1 Q100 years 64.5		
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Key

- Proposed Swale
- Indicative Overland Flow Route
- Site Boundary (Indicative Only)
- Solar Panels

Swale Details

- (a) Total length of swales = 167 m.
- (b) 0.1m Freeboard. Cross sectional area available for storage = 0.22 m².
- (c) Total storage volume of proposed swales = 232 x 0.22 = 36.7 m³.

Notes

- 1. Based on MK Surveys - Topographical Survey - 20444-1.
- 2. Based on Lightsource Renewable Energy Ltd - Proposed Layout - ACR_01_Rev5.

C	06/02/15	Drawing revised to updated layout	MWS
B	28/01/15	Drawing revised to updated layout	MWS
A	24/12/14	Project title updated	MWS
Rev	Date	Description	Initials

Client

Lightsource Renewable Energy

Project

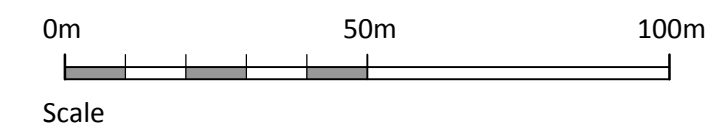
**Proposed Solar Park,
Land West of Delph Road**

Drawing Title

Proposed Drainage Arrangements

Drawing No. **L335/6** Rev C

Date	December 2014
Scale	1:1250 @ A1
Drawn By	MWS
Checked By	GE
E-Mail	geves@pfapl.com
File Ref.	\\Drawings\L335-06.dwg



LAND WEST OF DELPH ROAD SOLAR FARM

DRAINAGE CHECK SHEET

Section 1 INFORMATION ABOUT THE SITE

The development of this site from agricultural farmland to a solar park may have implications upon how the site drains. The soil is no longer being worked and rainfall may not infiltrate as effectively as in the past. Solar Farms are also relatively new features on the landscape and therefore there is limited experience as to how they may change rainwater runoff regimes.

This Simple Check Sheet enables review and recording of the performance of the site in terms of rainfall runoff.

Swales have been constructed along the boundaries at the low points of the fields within the site to assist the control of rainwater runoff. These are shown on the attached Plan L335/6 dated December 2014.

Section 2 USING THE CHECK SHEET

Maintenance Staff who undertake periodic inspections of the panels should be able to use this drainage review as part of undertaking other operational checks or if there are notable rainfall-runoff events that may have caused local issues.

Each feature is referenced as indicated on the attached Plan L335/6 dated December 2014. The Check Sheet should mostly be a tick sheet and some of the notes made should be for information only but some may require action.

The Check Sheet should be filed along with other site operation information and be available for future use by a drainage specialist if required.

Section 3 THE CHECK SHEET

- | | |
|--|-----|
| 1. Do any parts of the swales contain standing water? | Y/N |
| 2. Is any water overflowing from the swales? | Y/N |
| 3. Are any of the swales overgrown or silted up? | Y/N |
| 4. Has there been recent excessive rainfall or local flooding issues near to the site? | Y/N |
| 5. Are rivulets (small channels) forming or is there soil erosion due to rainwater? | Y/N |

Section 4 RESULTS (e.g. what to do next)

If YES to number 3 above, maintenance may be required.

If yes to 4 & 5 then further investigation may be required and consultation with a drainage engineer would be prudent.