



Wrexham Solar Development

Surface Water Management Plan

Novus Renewable Services Ltd

REPORT REF: 258/SP12 (v3)

April 2021

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1 Introduction

1.1 Background

This is a Surface Water Management Plan (SWMP) to support the Outline Planning Application for a solar farm, adjacent to an existing solar farm north of the Maelor gas works near Wrexham. A Flood Consequence Assessment has also been prepared for the development.

Corylus Planning and Environmental Ltd (Corylus) has been instructed by Novus RS Ltd to undertake this assessment.

1.2 Sources of Information for the Report

This Report has been informed by the following:

- Scoping Assessment by Hydro-Logic in 2019;
- Site visit on 19th November 2020 including infiltration testing for an adjacent Site;
- Flood modelling undertaken for the River Clywedog in support of this and other planning applications;
- Access to maps and other relevant information on publicly available internet sites.

1.3 Structure of this Report

This Report comprises the following Sections:

- Section 2 provides the Site Context and SuDS Selection Review;
- Section 3 describes the mitigation measures;
- Section 4 provides a Summary of the main findings

The following supporting Appendices are provided:

- Appendix A is the Site Investigation Report for an adjacent Site
- Appendix B is the Development Proposal
- Appendix C is the Application Form for the SuDS Approval Board (SAB)
- Appendix D is a Construction and Environment Management Plan (CEMP)

This is version 3 of the Report, the main changes from version 2 being the inclusion of the CEMP and revision of flood extent/depth maps, following rerunning of the flood model.

2 Site Context and Evolution of SuDS Strategy

2.1 Site Context

The location of the Site is shown in Figure 2-1 along with the topography. The lower parts of the Site are located on generally flat land adjacent to the River Clywedog. The more elevated parts of the Site are on land that slopes gently towards the river. The land is currently in agricultural use, though some buildings remain from its former use as an MoD facility. An aerial view of the Site given in Figure 2-2 showing how the Site wraps around the existing solar farm.

The Site comprises four fields where the solar arrays are to be installed. Images of the Site are shown in Figure 2-3 to Figure 2-6.

Figure 2-1: Location and topography of Site – outlined in red

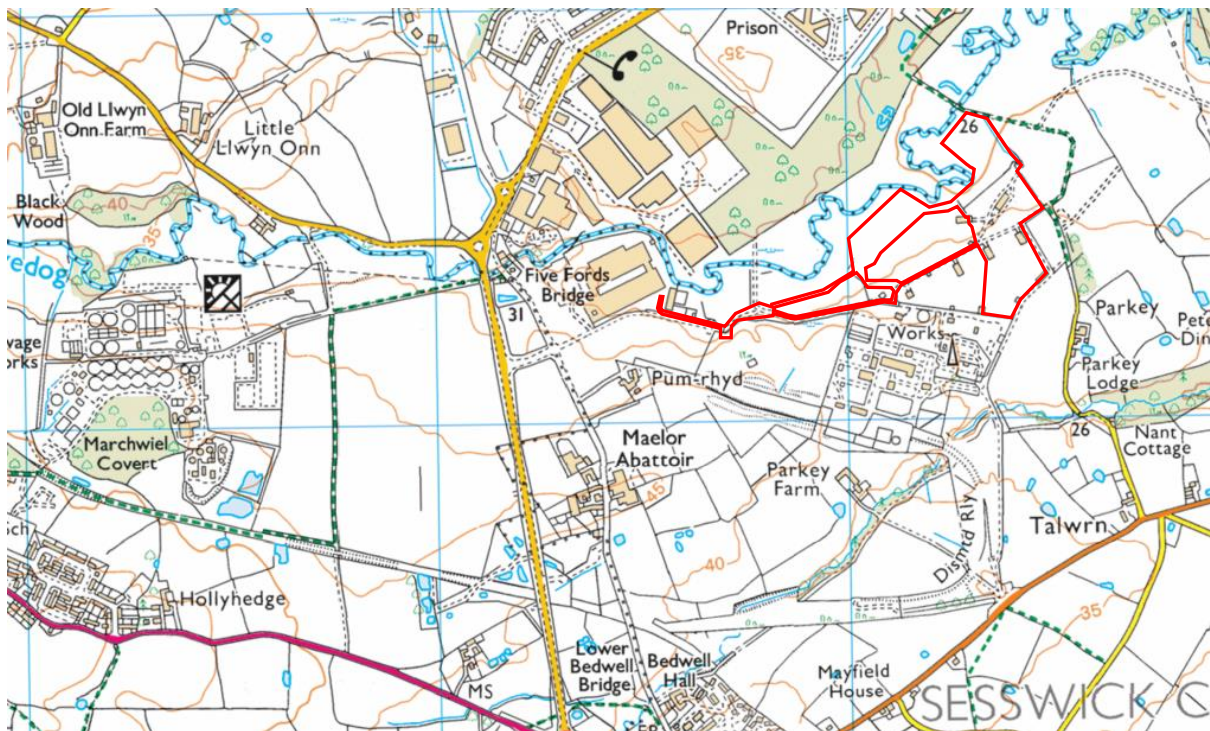


Table 2-1: Map Co-ordinates

Reference	Value
OS X (Eastings)	338371
OS Y (Northings)	348465
Nearest Post Code	LL13 0UN
Lat (WGS84)	N53:01:48 (53.029903)
Long (WGS84)	W2:55:13 (-2.920392)

Figure 2-2: Existing Site with proposed development outlined in red



Figure 2-3: Field 1A

(a) North towards river



(b) South towards Field 1B



Figure 2-4: Field 1B

(a) East towards MoD building



(b) South towards Field 1C



Figure 2-5: Field 1C

(a) South-west towards existing solar farm



(b) North towards Battery facility



Figure 2-6: Field 2 – view to north from existing solar farm



2.2 Flood Context

The flood context is described in the FCA that is being submitted alongside this SWMP. NRW provided pre-application comments on v1 of the FCA, submitted in February 2021. The model has been refined by way of a response to the NRW comments. A v2 of the FCA has now been prepared and will be submitted with this Application. Flood extent maps have been updated in this SWMP. The FCA has incorporated the detailed hydraulic modelling for the River Clywedog. This in turn has enabled a refinement of the flood extents for the Site. An extract is shown in Figure 2-7 for the 1% Baseline and in Figure 2-8 for the 0.1% Baseline model.

The main findings are as follows for the 1% AEP:

- Flood extents are broadly similar to those of NRW within the Site. However, there are substantial differences downstream of the Site that likely reflect the more detailed modelling undertaken by Corylus compared to the generalised modelling upon which the NRW flood maps have been based.
- Flood depths are in a range of 0 to 0.25 m for the majority of the flooded areas in Fields 1A and 2. There is a small area with depths up to around 0.75 m at the north-east area of Field 1A due to a topographic depression. However, within the area of panels, shown by the dashed lines, the maximum depth is around 0.5 m.

The main findings are as follows for the 0.1% AEP:

- As with the 1% flood, flood extents are broadly similar to those of NRW within the Site (Figure 2-8). However, the differences downstream of the Site are less noteworthy with flooding on the left bank downstream of the crossing point.
- Flood depths are greater than for the 1% AEP flood, with most of the flooded area being in a depth range of 0.25 to 0.5 m with maximum depths of just over 1 m. However, within the area of panels, shown by the dashed lines, the maximum depth is around 0.75 m.

The layout has been informed by the 1% AEP model runs with allowance for climate change and blockage.

Figure 2-7: Flood depth for 1% AEP

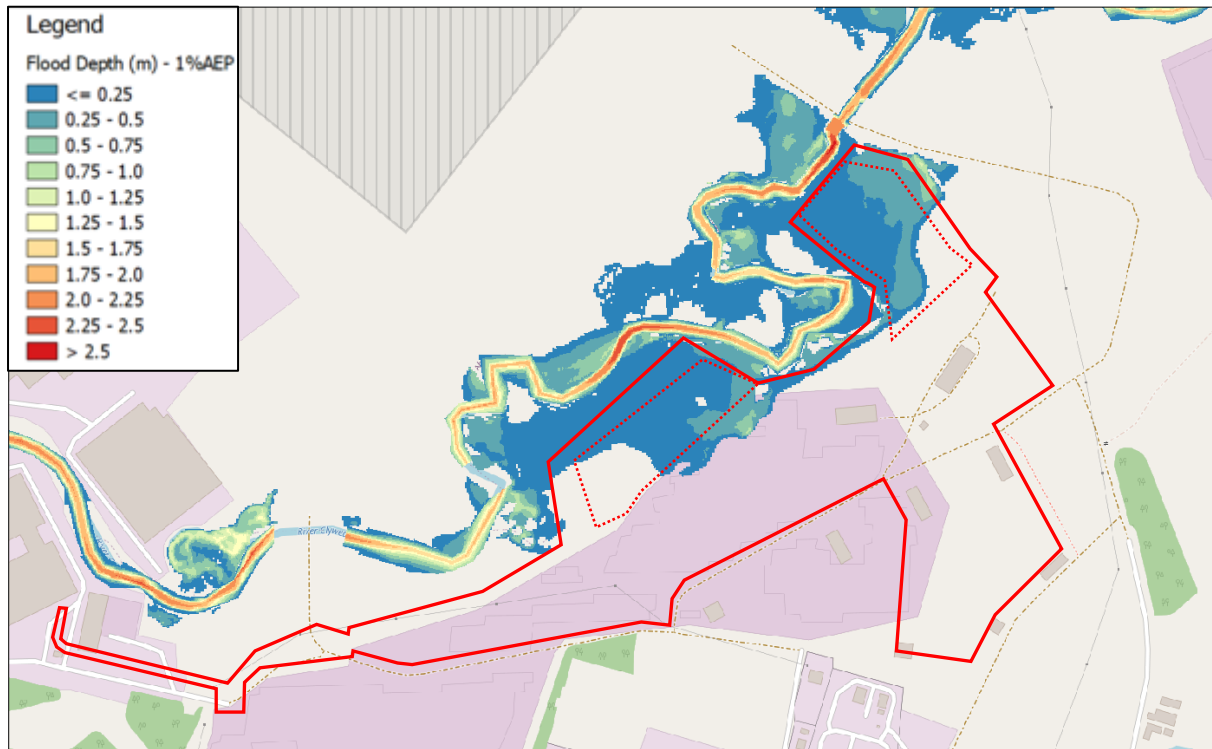
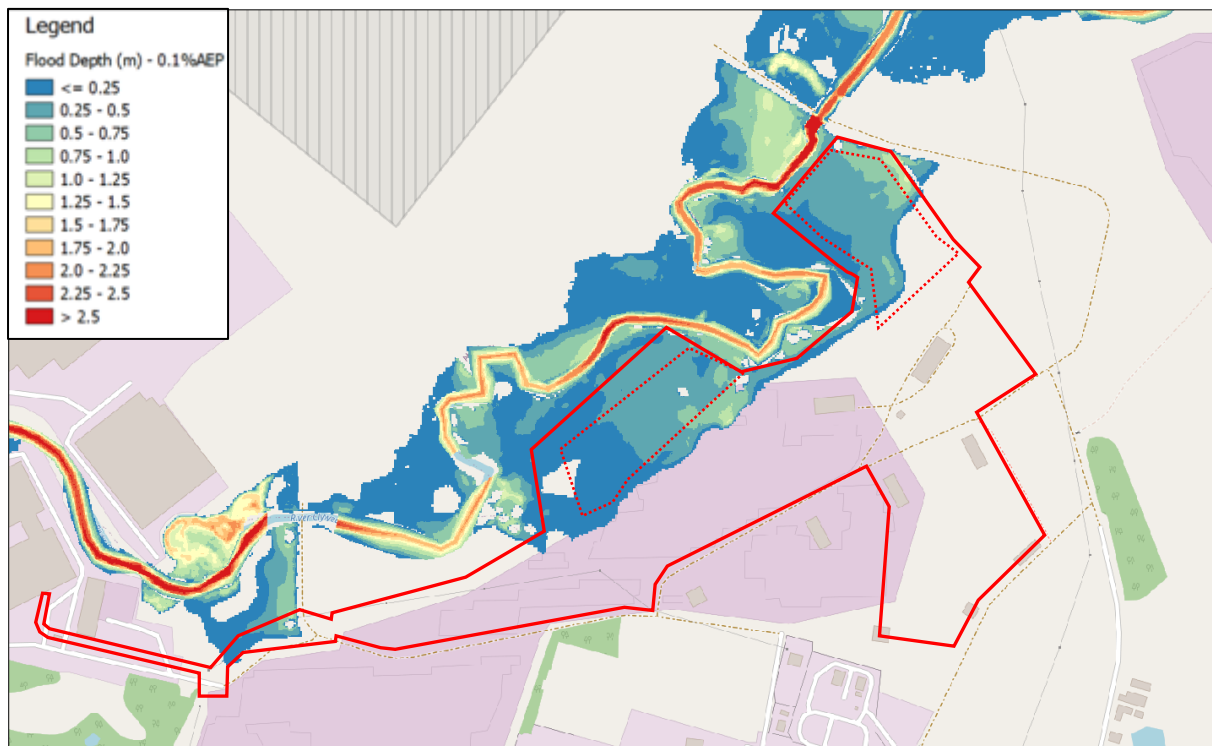


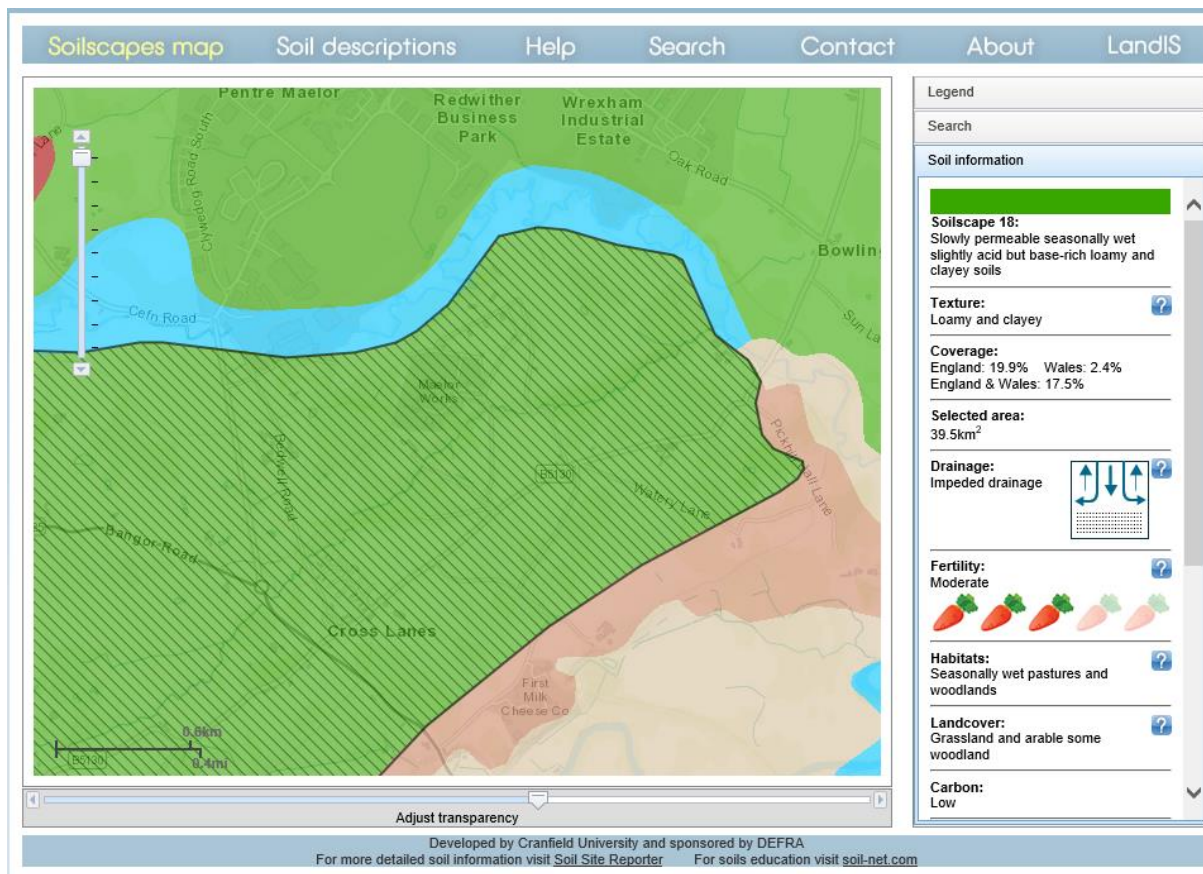
Figure 2-8: Flood depth for 0.1% AEP



2.3 Soil Context

The soil properties for the Site are illustrated in Figure 2-9 from the NSRI Soilscape web site. This shows that the soils over the entire Site are described as having “Impeded drainage”. Site investigations were undertaken specifically for this application. This entailed the start of an infiltration test in Field 1C, to inform of the sizing of possible infiltration systems. However, the test was aborted following a fall in water level of only 5 mm over 3 hours on the first fill. The clay fraction is clear in the arisings and from the very smooth cut faces within the trial pit (Figure 2-9).

Figure 2-9: Soil Properties (NSRI Soilscape Website)



Infiltration testing was also undertaken for an adjacent Site to the west of the proposed Solar Farm. The results of these investigations are presented in Appendix A since the findings are useful for some of the isolated impermeable units that are located close to the test sites.

The results of the testing are shown in Table 2-2. The lowest value from the three tests on the adjacent site (proposed car park) has been used for the permeable paving review, namely from Pit A at 3.05 E-06 m/s – equivalent to 11 mm/h.

Figure 2-10: Trial Pit in Field 1C – terminated due to low observed rates of infiltration



Table 2-2: Results from Infiltration Testing on Adjacent Site

Pit	Proposed development	Test 1	Test 2	Test 3
A	Car park	8.84E-06	overnight	3.05E-06
B	Car park	1.47E-05	overnight	7.42E-06
C	Car park	8.9E-06	overnight	3.94E-06

2.4 SuDS Selection Review

The SuDS selection Review demonstrates the way in which SuDS measures are to be provided to mitigate the impacts of the development.

The components of the development are shown in Appendix B (Drawing by Corylus, ref WREX/258/06/1L, dated February 2021) and comprise the following:

- Installation of solar panels
- Gravel tracks to provide internal access and around the batteries, transformers and ancillary stores;
- Impermeable surfaces comprising the rooves and concrete pads for the batteries, transformers and ancillary stores; and
- Soil mound for storage of top soil removed for creation of roads and other infrastructure.

Our general experience relating to the **installation of solar panels** over many years is that there is no increase in runoff, except in specific circumstances. In general, and especially on flat sites (such as this one) runoff from solar panels is able to infiltrate into the soil either beneath the panels, or under adjacent panels. This is aided by the rainwater gap between the panels as shown in Figure 2-11. On sites with steep slopes, especially where the panels align down the gradient, increased rates of runoff may occur and require mitigation. Since this is not the case for this site, **there is no**

requirement for any mitigation of runoff from solar panels. This is supported by the observations on the existing solar site where there was no evidence of increased runoff or waterlogging under the panels (Figure 2-12).

Figure 2-11: Typical section through solar array showing rainwater gap between adjacent panels

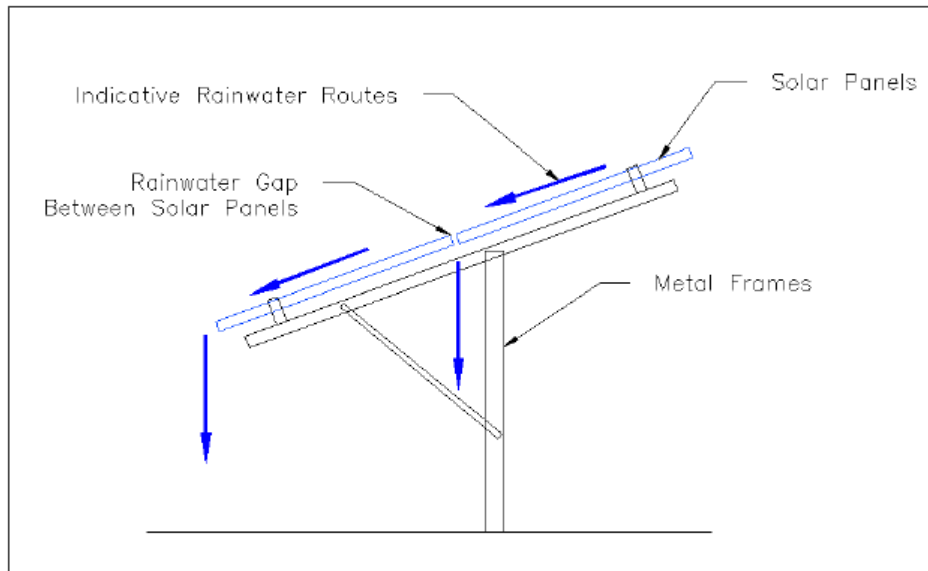


Figure 2-12: Ground conditions on the existing solar site



The use of **gravel chippings** for areas around the infrastructure and for the internal access tracks is commonplace on solar farms; a typical arrangement is shown in Figure 2-13. The chippings provide a permeable surface, through which rainfall may penetrate and infiltrate into the underlying soils. **No further mitigation is required for these “permeable” areas of gravel chippings.**

Figure 2-13: Typical layout showing gravel chippings around infrastructure on concrete pads



The **electrical infrastructure** comprises a customer substation, Battery Storage containers plus transformers and ancillary stores. These units are all mounted on concrete pads which are impermeable and will require mitigation. The perimeter fence will be set on a concrete base, the runoff from which will also require mitigation.

The **soil storage mound** will be required so that topsoil can be retained within the Site, ultimately for restoration of the Site. The soil mound is expected to have reasonable infiltration properties – given that it is composed of topsoil, placed without compaction and will likely promote a good sward. Furthermore, it is located some distance from any downslope external site boundaries. **No further mitigation is thus required for the soil storage mound.**

A SuDS Selection Review is presented in Table 2-3 by way of a summary of the proposed approach to mitigating runoff from the development surfaces. This confirms that some form of attenuation system provides the only viable SuDS scheme.

Table 2-3: SuDS Selection Review

SuDS Component	Appropriate	Comment
Rainwater Harvesting Systems	No	Not appropriate for nature of development.
Green Roofs	No	Not appropriate for nature of development
Infiltration Systems	Partial	Site investigation shows that soils are unsuitable for infiltration over most of the Site. However, they are suitable for isolated infrastructure on the west of the Site.
Proprietary Treatment Systems	No	Runoff from building rooves has low levels of contamination.
Filter Strips	Potential	Runoff from new impermeable surfaces will flow via gravelled areas into the attenuation device which will provide an opportunity for treatment.
Filter Drains	No	Not deemed necessary.
Swales	Yes	Used for both attenuation and conveyance.
Bioretention Systems	No	Not necessary.
Trees	Yes	Existing trees around site perimeter to be retained.
Pervious Pavements	No	Site investigations confirms that soils were, in general, not suitable.
Attenuation Tanks	No	Unsuitable topography
Detention Basins	Yes	Basins proposed for runoff from rooves and hard standing.
Pond/Wetlands	Potential	Attenuation basin and ditch likely to be preferentially wet with potential ecological benefit.

Based on Table 1.1 (CIRIA, 2015)

3 Mitigation Measures

3.1 Impermeable Surfaces

The SuDS selection review presented in Section 2.4 has shown that the only aspects of the development that require mitigation are the impermeable surfaces associated with the electrical infrastructure. The relevant areas are shown in Table 3-1.

Table 3-1: Impermeable surfaces

Component	Loc.	Unit area	Nr	Gross area	Comment/source
Batteries	1C	30	8	240	Drains to proposed swale
Battery PCS	1C	70	2	140	Drains to proposed swale
Transformer	1C	15	1	15	Drains to proposed swale
ISO Container Spares Store	1C	15	1	15	Drains to proposed swale
Ancillary electrical buildings	1C	10	2	20	Drains to proposed swale
Battery store fence (125 m concrete base 0.4 m wide)	1C			50	Drains to proposed swale
Sub-total (Field 1C)-	1C			480	10% creep added in modelling
Transformer (Field 1B)	1B	15	1	15	Some attenuation in swale prior to discharge
Transformer (Field 2)	2	15	1	15	Infiltration area
Customer Substation	Entrance	26	1	26	Infiltration area
Ancillary electrical buildings	Entrance	10	1	10	Infiltration area
Sub-total (isolated infrastructure)				66	10% creep added in modelling
GRAND TOTAL				546	

3.2 Greenfield runoff

Greenfield runoff has been estimated using the IH124 procedures (Marshall and Bayliss, 1994). The input data and results are presented in Table 3-2. These are “specific” rates of runoff expressed in l/s/ha. This is necessary because the equation used is only valid for catchments with a minimum area of 0.5 km². The SOIL index has been informed by an infiltration test undertaken on 19th November 2020. Although the infiltration rate could not be computed, the fall of water level of only 5 mm in a period of 3 hours confirms the very low rates of infiltration and correspondingly high rates of runoff. On this basis, the soils have been put in the soil class 5.

Table 3-2: Greenfield and development rates of runoff

AREA	0.5 (see text)	km2
SAAR4170	685	mm
SOIL	0.50	-
URBAN	0.00001	-
CWI	100	mm
REGION	Wales	

Return period (years)	Runoff (l/s/ha)	
	rural	impermeable
2	5.0	19.0
20	8.8	25.0
25	9.2	25.2
50	10.4	26.0
100	11.7	26.8

3.3 Components of SuDS

It is proposed that surface runoff from the impermeable surfaces in Field 1C be directed into an attenuation swale as shown in Figure 3-1 and Figure 3-2. For the most part, the swale is a linear feature adjacent to the existing road. However, at its western end, the swale is widened to create a small basin so as to provide the required area. Since this implies flow over an existing road, the attenuation swale will also receive runoff from a portion of the road surface. The relevant area of road that is adjacent to the proposed swale has a length of 120 m and nominal width of 3 m giving an area of 360 m².

Whilst this component of runoff has been incorporated into the analysis, it is inappropriate to use the greenfield rate of runoff for the combined area of new and existing impermeable surfaces. The “allowable peak outflow” is thus a weighted value reflecting both the new impermeable areas and the existing road surface as shown in Table 3-3 (final column).

Table 3-3: Allowable rates of runoff from the attenuation swale

	New impermeable	Existing road	Total
Area (ha)	0.048 ²	0.036	0.084
<i>Specific runoff (l/s/ha)</i>			
50% AEP	5.0	19.0	11.63
3.33% AEP ¹	9.2	25.2	16.78
1% AEP	11.7	26.8	18.88
<i>Runoff (l/s)</i>			
50% AEP	0.24	0.69	0.92
3.33% AEP ¹	0.44	0.91	1.35
1% AEP	0.56	0.97	1.53

Notes

- 1 *Actually AEP of 4% (1 in 25) since 3.33% not tabulated*
- 2 *Excludes the urban creep of 10% that is used in the modelling*

Outflow from the attenuation feature is then conveyed along a small ditch as shown in Figure 3-3. For the most part, this appears to be an existing flow route which falls by around 1 m over a distance of 200 m (gradient of 0.005) but which may need to be enlarged in places. The ditch would outfall to an existing riparian watercourse as shown in Figure 3-4 close to the boundary between fields 1A and 1B. Although a watercourse was evident and is shown in the topographic survey, there was no flow at the time of the visit. The watercourse flows in a broadly northerly direction to its confluence with the River Clywedog.

A further impermeable surface for a transformer is located in the north corner of field 1B. With an area of 15 m², this is too small for any practical attenuation. However, it is proposed to route runoff from the roof to the small ditch where some attenuation is likely to occur prior to it flowing into the riparian watercourse.

Figure 3-1: Principal components of SuDS attenuation

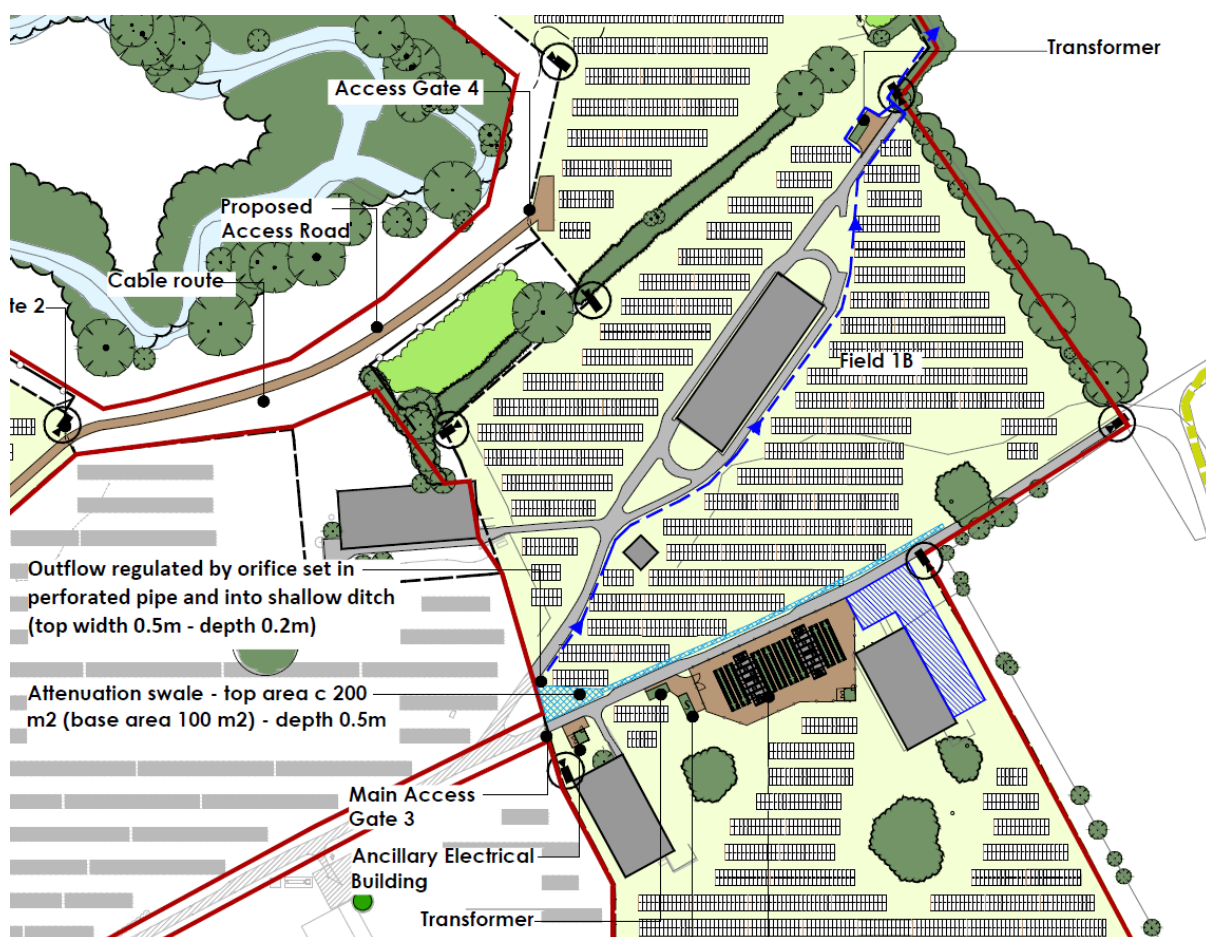


Figure 3-2: Proposed SuDS components in relation to existing road

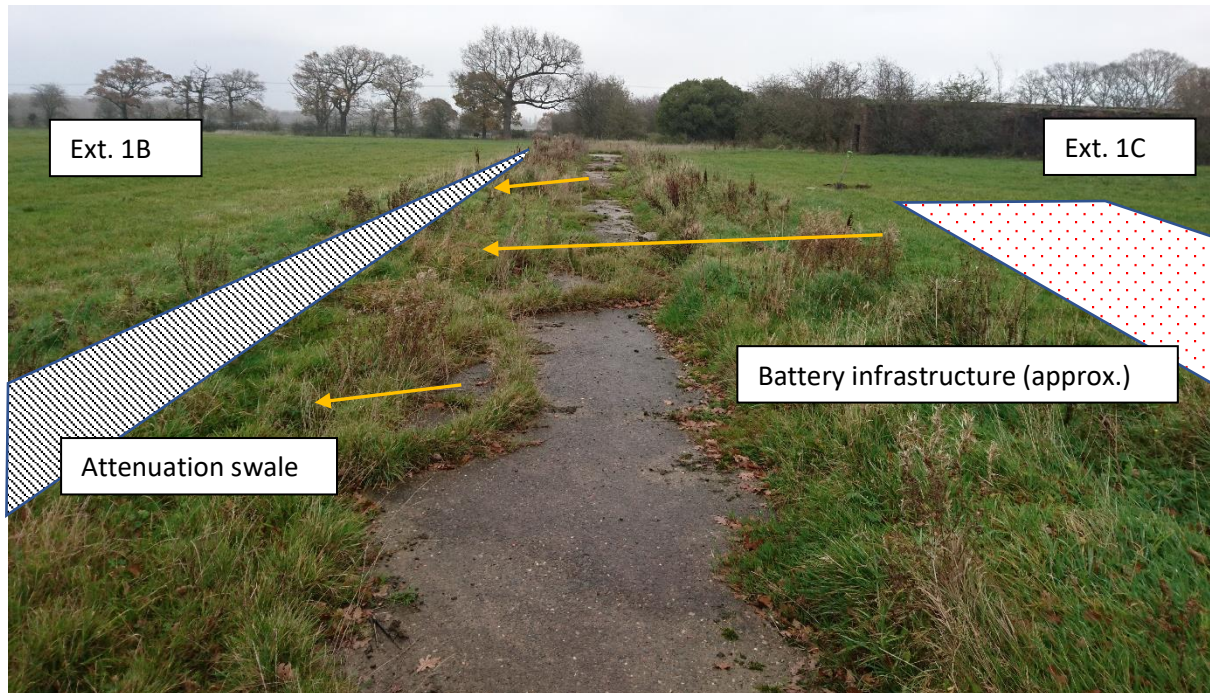
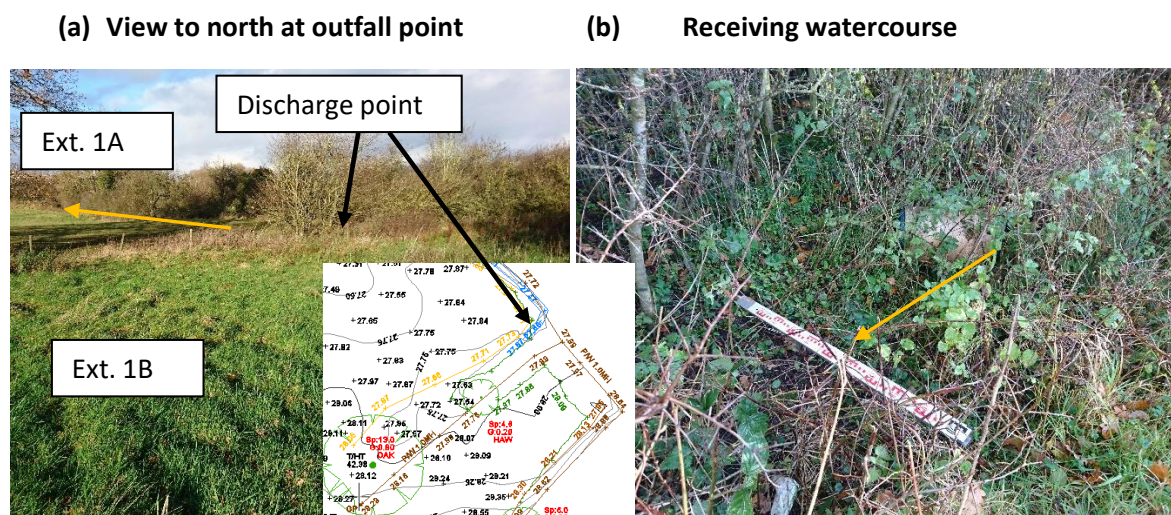


Figure 3-3: Proposed SuDS component – small ditch viewed to south west in 1B



Figure 3-4: Proposed SuDS component – outfall to existing watercourse



Inset is from topographic survey and shows riparian watercourse in blue

There are three further isolated infrastructure components as shown in Table 3-1, namely a Transformer for Field 2 and the Customer sub-station and Ancillary Electrical Building near the Site entrance. These are too small for any practical attenuation and so infiltration systems are proposed for runoff mitigation and informed by site specific testing on the adjacent Site.

3.4 Sizing of SuDS Components

3.4.1 Proposed impermeable surfaces in Field 1C

The dimensions of the attenuation swale have been determined with a routing model which has been coded as a generalised spreadsheet by Corylus. It has been used on numerous similar projects and has been approved for use by regulators. The spreadsheet simulates the water balance of the attenuation device, accounting for any inflows and for outflows from up to two devices, such as orifice and weir. An iterative approach is used in the investigation of trial combinations of its volume, outflow device, storm duration or other features.

The assumptions that are embodied in its usage are:

- Point rainfalls have been obtained from the FEH Web Service and based on FEH2013.
- These have been increased by 20% to allow for climate change over the design life of the scheme.
- A runoff coefficient of 100% has been used for the new impermeable surfaces and the existing road. In practice, they may be slightly lower since the runoff from the new impermeable surfaces will need to traverse a gravel strip prior to entering the swale.
- The model time step was 15 minutes.
- Pre-development (i.e. greenfield) and allowable runoff rates were established as shown in Sections 3.2 and 3.3.

- Attenuation storage is provided in a roadside swale with depth of 0.5 m, nominal bottom width of 1 m and top width of 2 m – implying a 1 in 1 side slope. Additional storage is provided through a “basin” at the end of the swale, as shown in Figure 3-1.
- The outflow is to a ditch and is regulated by an orifice with diameter of 0.0325 m.

A critical duration analysis has been carried out for the storm with AEP of 50% (1 in 2 annual probability). The results are shown in Table 3-4 and confirm that the critical duration is a nominal 4 hour duration.

The model has been run for three annual probabilities, namely AEP of 1%, 3.33% and 50% (1 in 100, 1 in 30 and 1 in 2). The results are shown in graphical form in Figure 3-5 with a summary in Table 3-5. This confirms that the peak outflow is lower than the allowable peak for the three probabilities considered.

In order to minimise the risk of blockage, the orifice is to be set at the downstream end of a 100 mm perforated pipe, wrapped in geotextile and placed in a gravel trench on the upstream face of the outlet structure (Figure 3-6). This should ensure that the orifice remains unobstructed and that any maintenance that is required would be to address possible blinding of the gravel around the inlet pipe.

Table 3-4: Critical duration analysis for AEP of 50%

Duration (h)	Peak outflow (l/s)	Peak stage (m)
2.25	0.87	0.162
4.25	0.88	0.163
6.25	0.86	0.159

Table 3-5: Summary of results for critical duration of 4 hours

Probability	Peak outflow (l/s)	Allowable (l/s)	Peak Outflow < Allowable
1% (1 in 100)	1.44	1.53	Yes
3.33% (1 in 30)	1.27	1.44	Yes
50% (1 in 2)	0.88	0.92	Yes

Figure 3-5: Attenuation model results

(a) AEP of 1% (1 in 100 annual probability)

LEVEL POOL ROUTING (v2)

Wrexham Solar

T=100 yrs

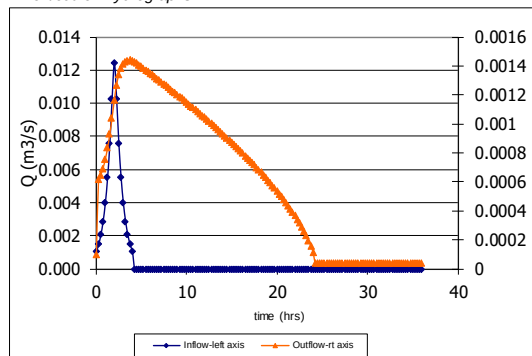
4.25h

User Inputs

Description	Value		
Initial surface area of res/pond	100	m ²	
Area increase per m rise in level in	200	m ²	
time step (ΔT)	0.25	h	
Head increment for sd relationship	0.1	m	
device 1 width/diameter, b	0.0325	m	
choose type (device 1)	orifice		
angle for V notch (weir 1)	0	degrees	
device 2 width/diameter, b	0	m	
choose type (device 2)	Ogee weir		
angle for V notch (weir 2)	0	degrees	
device 2 above device 1 by:	0	m	
Area(s) of runoff (m2)	528	360	
Runoff coefficient for each area	100.0%	100.0%	
Climate change factor	1.20		
Greenfield/permitted rate of runoff	18.9	l/s/ha	

Device Details			
Device characteristics		dev. 1	dev. 2
selected device		orifice	Ogee weir
a in discharge characteristic ($Q=aH^b$)		0.002	0.000
b in discharge characteristic ($Q=aH^b$)		0.5	1.5
weir type		a	b
orifice		0.002205	0.000000
rect thin plate weir with side contractions		0.062266	0.005262
vee-notch		0.000000	0.000000
rectangular profile		0.046825	0.000000
round nose horiz crested weir - floodbank		0.055375	0.000000
triangular profile crump		0.064435	0.000000
Ogee weir		0.068201	0.000000

Inflow/outflow hydrographs



Max Storage	65	m ³	Max O	0.0014	m ³ /s
Max depth	0.434	m	Max O	1.44	l/s
Runoff vol	74	m ³	Permitted	1.68	l/s

Auxiliary Table

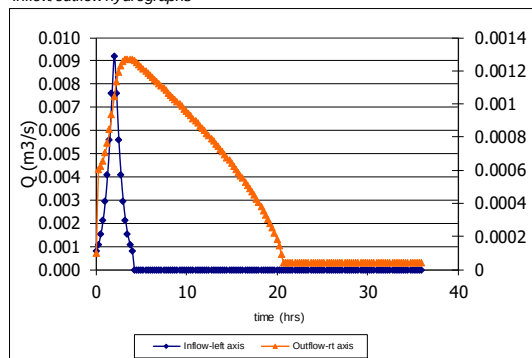
depth above device (head) (m)	S as a function of H (m ³)	dev 1 (m ³ /s)	dev 2 (m ³ /s)	outflow f(H)	G (m ³ /s)
H	S(H)			O	G
0	0	0.0000	0.0000	0.0000	0
0.1	11	0.0007	0.0000	0.0007	0.013
0.2	24	0.0010	0.0000	0.0010	0.027
0.3	39	0.0012	0.0000	0.0012	0.044
0.4	56	0.0014	0.0000	0.0014	0.063
0.5	75	0.0016	0.0000	0.0016	0.084
0.6	96	0.0017	0.0000	0.0017	0.108
0.7	119	0.0018	0.0000	0.0018	0.133
0.8	144	0.0020	0.0000	0.0020	0.161
0.9	171	0.0021	0.0000	0.0021	0.191
1	200	0.0022	0.0000	0.0022	0.223

(b) AEP of 3.33% (1 in 30 annual probability)

LEVEL POOL ROUTING (v2)		Wrexham Solar		T=30 yrs	
				4.25	h
User Inputs					
Description	Value				
Initial surface area of res/pond	100			m ²	
Area increase per m rise in level in	200			m ²	
time step (ΔT)	0.25			h	
Head increment for sd relationship	0.1			m	
device 1 width/diameter, b	0.0325			m	
choose type (device 1)	orifice				
angle for V notch (weir 1)	0			degrees	
device 2 width/diameter, b	0			m	
choose type (device 2)	Ogee weir				
angle for V notch (weir 2)	0			degrees	
device 2 above device 1 by:	0			m	
Area(s) of runoff (m2)	528			360	
Runoff coefficient for each area	100.0%			100.0%	
Climate change factor	1.20				
Greenfield/permitted rate of runoff	16.8			l/s/ha	

Device Details			
Device characteristics		dev. 1	dev. 2
selected device		orifice	Ogee weir
a in discharge characteristic ($Q=aH^b$)		0.002	0.000
b in discharge characteristic ($Q=aH^b$)		0.5	1.5
weir type		a	b
orifice		0.002205	0.000000
rect thin plate weir with side contractions		0.062266	0.005262
vee-notch		0.000000	0.000000
rectangular profile		0.046825	0.000000
round nose horiz crested weir - floodbank		0.055375	0.000000
triangular profile crump		0.064435	0.000000
Ogee weir		0.068201	0.000000

Inflow/outflow hydrographs



Max Storage	48	m ³	Max O	0.0013	m ³ /s
Max depth	0.340	m	Max O	1.27	l/s
Runoff vol	55	m ³	Permitted	1.49	l/s

Auxiliary Table

depth above device (head) (m)	S as a function of H (m ³)	dev 1 (m ³ /s)	dev 2 (m ³ /s)	outflow f(H)	G (m ³ /s)
H	S(H)			O	G
0	0	0.0000	0.0000	0.0000	0
0.1	11	0.0007	0.0000	0.0007	0.013
0.2	24	0.0010	0.0000	0.0010	0.027
0.3	39	0.0012	0.0000	0.0012	0.044
0.4	56	0.0014	0.0000	0.0014	0.063
0.5	75	0.0016	0.0000	0.0016	0.084
0.6	96	0.0017	0.0000	0.0017	0.108
0.7	119	0.0018	0.0000	0.0018	0.133
0.8	144	0.0020	0.0000	0.0020	0.161
0.9	171	0.0021	0.0000	0.0021	0.191
1	200	0.0022	0.0000	0.0022	0.223

(c) AEP of 50% (1 in 2 annual probability)

LEVEL POOL ROUTING (v2)

Wrexham Solar

T=2	hrs
4.25	h

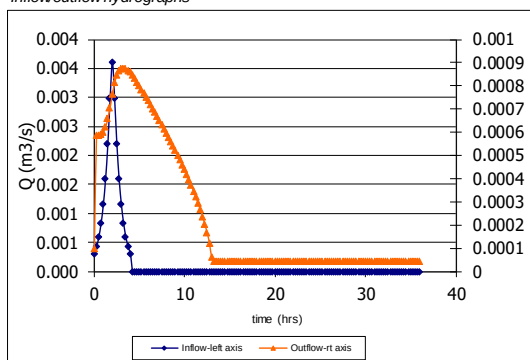
User Inputs

Description	Value	
Initial surface area of res/pond	100	m ²
Area increase per m rise in level in	200	m ²
time step (ΔT)	0.25	h
Head increment for sd relationship	0.1	m
device 1 width/diameter, b	0.0325	m
choose type (device 1)	orifice	
angle for V notch (weir 1)	0	degrees
device 2 width/diameter, b	0	m
choose type (device 2)	Ogee weir	
angle for V notch (weir 2)	0	degrees
device 2 above device 1 by:	0	m
Area(s) of runoff (m2)	528	360
Runoff coefficient for each area	100.0%	100.0%
Climate change factor	1.20	
Greenfield/permitted rate of runoff	11.6	l/s/ha

Device Details

Device characteristics	dev. 1	dev. 2
selected device	orifice	Ogee weir
a in discharge characteristic ($Q=aH^b$)	0.002	0.000
b in discharge characteristic ($Q=aH^b$)	0.5	1.5
weir type	a	b
orifice	0.002205	0.000000 0.5
rect thin plate weir with side contractions	0.062266	0.005262 1.5
vee-notch	0.000000	0.000000 1.5
rectangular profile	0.046825	0.000000 1.5
round nose horiz crested weir - floodbank	0.055375	0.000000 1.5
triangular profile crump	0.064435	0.000000 1.5
Ogee weir	0.068201	0.000000 1.5

Inflow/outflow hydrographs

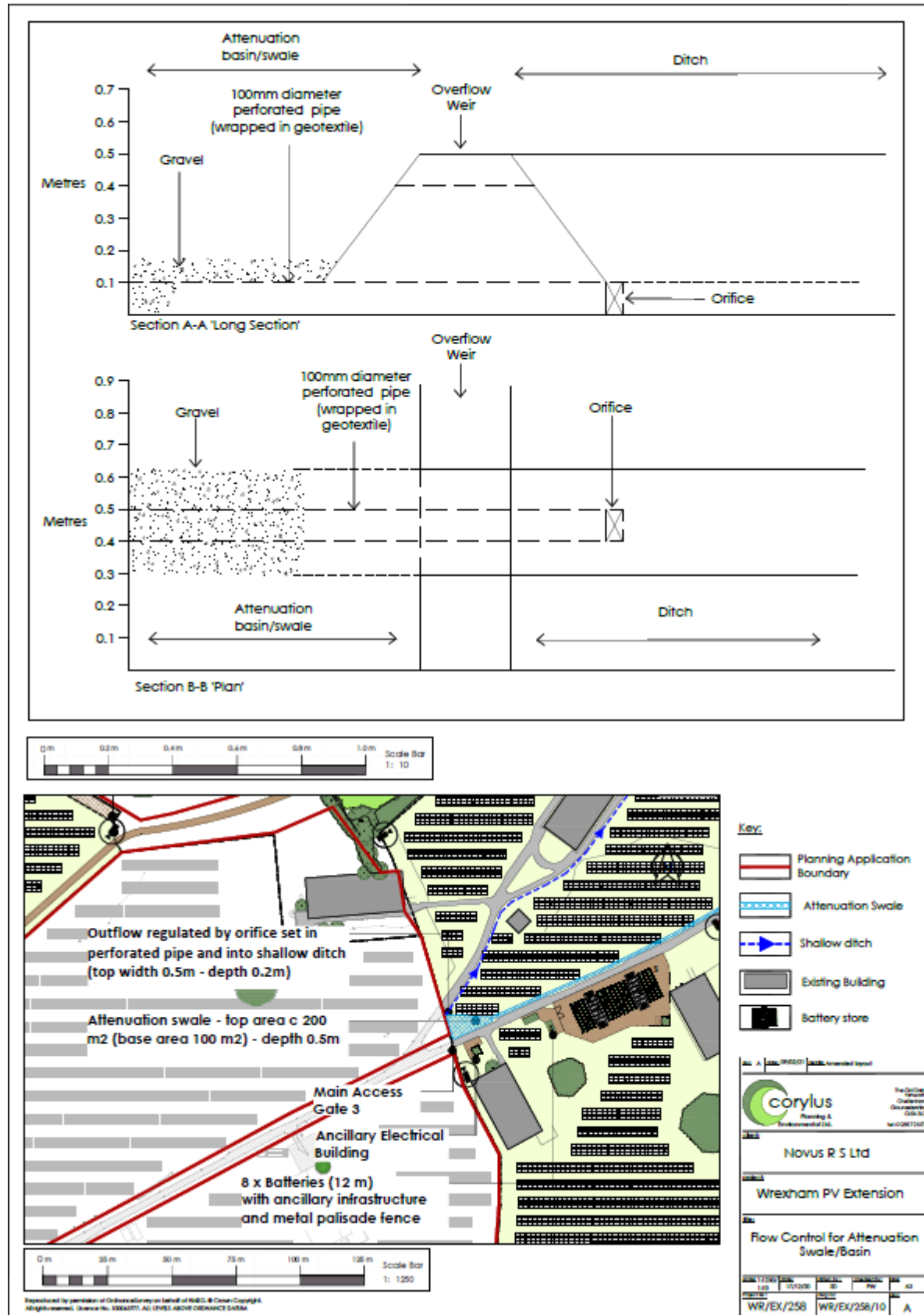


Max Storage	19	m3	Max O	0.0009	m3/s
Max depth	0.163	m	Max O	0.88	l/s
Runoff vol	21	m3	Permitted	1.03	l/s

Auxiliary Table

depth above device (head) (m)	S as a function of H (m3)	dev 1 (m3/s)	dev 2 (m3/s)	outflow f(H)	G (m3/s)
H	S(H)			O	G
0	0	0.0000	0.0000	0.0000	0
0.1	11	0.0007	0.0000	0.0007	0.013
0.2	24	0.0010	0.0000	0.0010	0.027
0.3	39	0.0012	0.0000	0.0012	0.044
0.4	56	0.0014	0.0000	0.0014	0.063
0.5	75	0.0016	0.0000	0.0016	0.084
0.6	96	0.0017	0.0000	0.0017	0.108
0.7	119	0.0018	0.0000	0.0018	0.133
0.8	144	0.0020	0.0000	0.0020	0.161
0.9	171	0.0021	0.0000	0.0021	0.191
1	200	0.0022	0.0000	0.0022	0.223

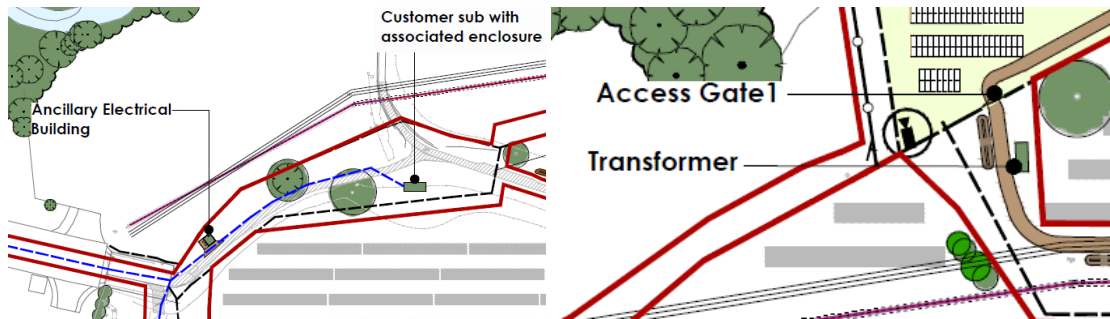
Figure 3-6: Outlet device for attenuation basin/swale



3.4.2 Isolated infrastructure elements

The isolated infrastructure elements have areas of and 15 m², 26 m² and 10 m² for the Field 2 Transformer, Customer Sub-station and Ancillary electrical buildings respectively (Figure 3-7). These areas are too small for any practical attenuation system. However, infiltration testing on the adjacent site (see Appendix A) confirmed the suitability of soils for shallow infiltration close to the location of the isolated infrastructure.

Figure 3-7: Isolated infrastructure components



The infiltration areas have been sized by reference to the site-specific infiltration rates and the appropriate impermeable area. The sizing makes use of a generalised spreadsheet that is based on the SuDS Manual (CIRIA, 2015). The analysis uses the following assumptions:

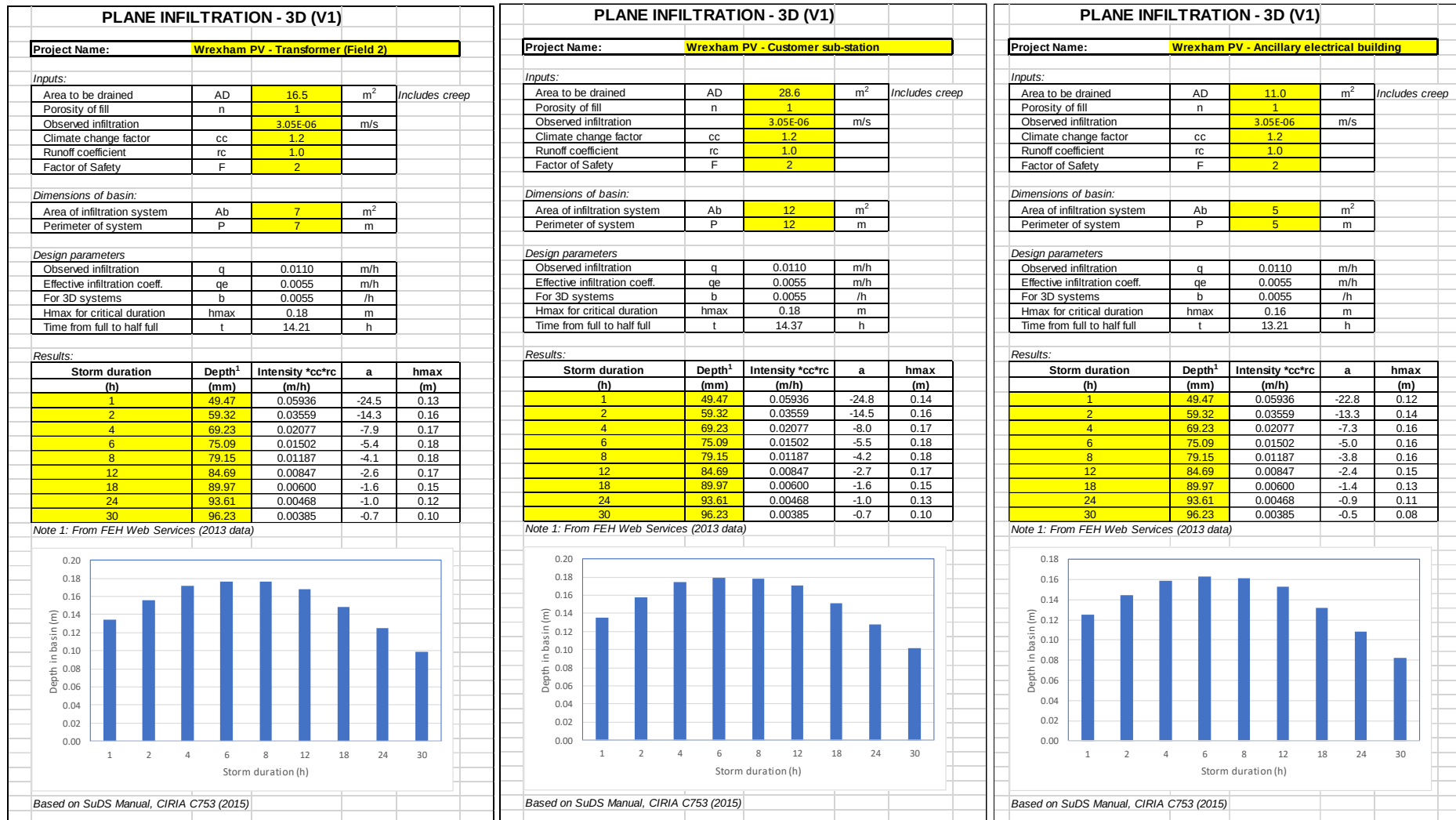
- Point rainfall, based on FEH2013 data with an AEP of 1% (1 in 100)
- Infiltration rate based on that from the site-specific testing
- Factor of Safety of 2.0 – consistent with the small area and limited impacts from any surcharge but higher than the recommended value of 1.5 since the tests were not undertaken at the precise location of the infrastructure;
- Runoff coefficient of 100% with all incident rainfall assumed to runoff;
- Climate change adjustment of +20%.

The results are presented in Figure 3-8 and summarised in Table 3-6 showing the required size of infiltration areas for mitigating the effects of surface water runoff. A small berm with height of 0.2m would be sufficient to deal with the maximum depths. The areas would also have a half-drain time of less than 24 hours.

Table 3-6: Sizing of infiltration areas for isolated infrastructure

Component	Impermeable area (m ²)	Infiltration area (m ²)	Max depth (m)	Half drain time (h)
Field 2 Transformer	16.5	7	0.18	14.2
Customer Sub-station	28.6	12	0.18	14.4
Ancillary electrical building	11.0	5	0.16	13.2

Figure 3-8: Sizing of Infiltration Areas for Isolated Infrastructure



3.5 Treatment stages

The new impermeable surfaces comprise rooves from which runoff should require limited treatment. The runoff will be conveyed to a swale, by flowing over and through a gravel surround which will provide a treatment opportunity. Runoff will then enter a swale whose area and length will ensure significant interaction with vegetation providing further treatment opportunities. Outflow from the attenuation basin will then flow in a small ditch to its outfall to the riparian watercourse where further treatment may apply.

The runoff from the isolated infrastructure should also require limited treatment. The proposed infiltration areas should be adequate for any treatment.

In view of this, no specific treatment stages are required.

3.6 Maintenance and Residual Risk

The maintenance requirements for the SuDS components are shown in Table 3-7 for swales, Table 3-8 for ponds and wetlands and Table 3-9 for infiltration basins. The components are mostly adjacent to internal roads which will facilitate access for maintenance. Furthermore, all solar sites are subject to a strict monthly maintenance schedule for operational reasons. The SuDS maintenance requirements can thus be included within this broader operational maintenance schedule.

The critical component of the SuDS is the orifice which regulates the outlet from the attenuation swale. A design has been offered in Section 3.4 that is considered to be at low risk of blockage. However, should it become blocked then the attenuation basin may rise above the design depth. Provision has been made for it to spill into the small ditch and thence to the discharge point to the riparian watercourse. The off-site risks of such an occurrence are small; this follows from the attenuation that will have taken place in the attenuation swale and the distance to any flood receptors.

The residual risks arise from failure to undertake the required maintenance and from storms in excess of those for which the scheme has been designed. For the reasons stated above, there is a high probability that maintenance will be undertaken on a regular basis and be effective in ensuring the operability of the SuDS devices.

Should storms in excess of the design storm occur, then the impacts on others are likely to be negligible. This follows from the fact that excess flows are likely to be captured in the attenuation swale/basin. The system has a design freeboard of 0.1 m for the 1% AEP event with excess flows able to escape via an overflow spillway. Furthermore, any surcharging of the attenuation swale and consequent spill would be subject to some attenuation and would need to flow for over 200 m before reaching the outfall point on the riparian watercourse. Potential flow paths have been sketched on Figure 3-9.

3.7 Flood and drainage issues during construction

The principal risk during construction relates to ground conditions, which is referenced within the CEMP, provided as Appendix D.

Table 3-7: Operation and maintenance requirements for swales

Maintenance schedule	Required action	Typical frequency
Regular maintenance	Remove litter and debris	Monthly, or as required
	Cut grass – to retain grass height within specified design range	Monthly (during growing season), or as required
	Manage other vegetation and remove nuisance plants	Monthly at start, then as required
	Inspect inlets, outlets and overflows for blockages, and clear if required	Monthly
	Inspect infiltration surfaces for ponding, compaction, silt accumulation, record areas where water is ponding for > 48 hours	Monthly, or when required
	Inspect vegetation coverage	Monthly for 6 months, quarterly for 2 years, then half yearly
	Inspect inlets and facility surface for silt accumulation, establish appropriate silt removal frequencies	Half yearly
Occasional maintenance	Re-seed areas of poor vegetation growth, alter plant types to better suit conditions, if required	As required 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 re-seeding	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
	Remove and dispose of oils or petrol residues using safe standard practices	As required

Table 17.1 from SuDS Manual (CIRIA, 2015)

Table 3-8: Operation and maintenance requirements for ponds and wetlands

Maintenance schedule	Required action	Typical frequency
Regular maintenance	Remove litter and debris	Monthly (or as required)
	Cut the grass – public areas	Monthly (during growing season)
	Cut the meadow grass	Half yearly (spring, before nesting season, and autumn)
	Inspect marginal and bankside vegetation and remove nuisance plants (for first 3 years)	Monthly (at start, then as required)
	Inspect inlets, outlets, bankside, structures, pipework etc for evidence of blockage and/or physical damage	Monthly
	Inspect water body for signs of poor water quality	Monthly (May – October)
	Inspect silt accumulation rates in any forebay and in main body of the pond and establish appropriate removal frequencies; undertake contamination testing once some build-up has occurred, to inform management and disposal options	Half yearly
	Check any mechanical devices, eg penstocks	Half yearly
	Hand cut submerged and emergent aquatic plants (at minimum of 0.1 m above pond base; include max 25% of pond surface)	Annually
	Remove 25% of bank vegetation from water's edge to a minimum of 1 m above water level	Annually
	Tidy all dead growth (scrub clearance) before start of growing season (Note: tree maintenance is usually part of overall landscape management contract)	Annually
	Remove sediment from any forebay.	Every 1–5 years, or as required
	Remove sediment and planting from one quadrant of the main body of ponds without sediment forebays.	Every 5 years, or as required
Occasional maintenance	Remove sediment from the main body of big ponds when pool volume is reduced by 20%	With effective pre-treatment, this will only be required rarely, eg every 25–50 years
Remedial actions	Repair erosion or other damage	As required
	Replant, where necessary	As required
	Aerate pond when signs of eutrophication are detected	As required
	Realign rip-rap or repair other damage	As required
	Repair / rehabilitate inlets, outlets and overflows.	As required

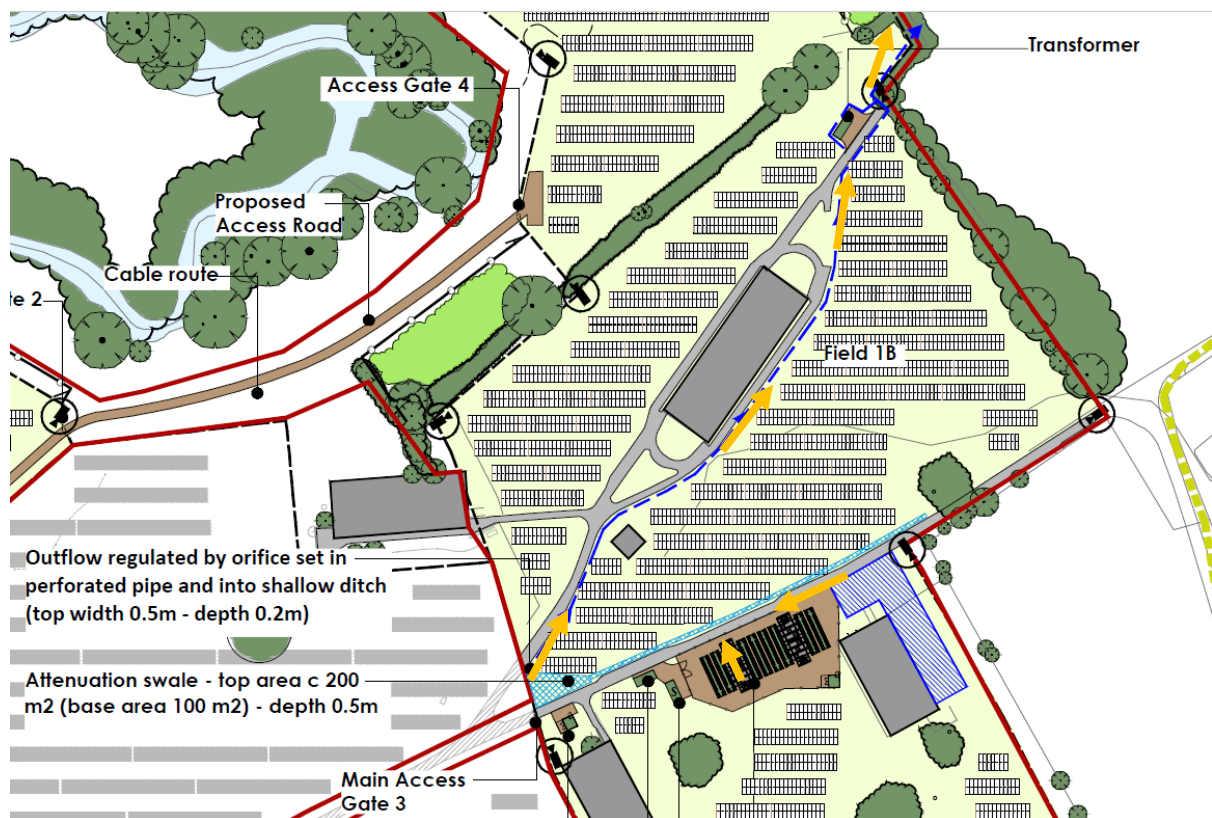
Table 23.1 from the SuDS Manual (CIRIA, 2015)

Table 3-9: Operation and maintenance requirements for infiltration basins

Maintenance schedule	Required action	Typical frequency
Regular maintenance	Remove litter, debris and trash	Monthly
	Cut grass – for landscaped areas and access routes	Monthly (during growing season) or as required
	Cut grass – meadow grass in and around basin	Half yearly: spring (before nesting season) and autumn
	Manage other vegetation and remove nuisance plants	Monthly at start, then as required
Occasional maintenance	Reseed areas of poor vegetation growth	Annually, or as required
	Prune and trim trees and remove cuttings	As required
	Remove sediment from pre-treatment system when 50% full	As required
Remedial actions	Repair erosion or other damage by reseedling or re-turfing	As required
	Realign the rip-rap	As required
	Repair or rehabilitate inlets, outlets and overflows	As required
	Rehabilitate infiltration surface using scarifying and spiking techniques if performance deteriorates	As required
	Relevel uneven surfaces and reinstate design levels	As required
Monitoring	Inspect inlets, outlets and overflows for blockages, and clear if required	Monthly
	Inspect banksides, structures, pipework etc for evidence of physical damage	Monthly
	Inspect inlets and pre-treatment systems for silt accumulation; establish appropriate silt removal frequencies	Half yearly
	Inspect infiltration surfaces for compaction and ponding	Monthly

Table 13.2 from the SuDS Manual (CIRIA, 2015)

Figure 3-9: Exceedance flow routes



4 Summary

This is a Surface Water Management Plan (SWMP) to support the Outline Planning Application for a solar farm, adjacent to an existing solar farm north of the Maelor gas works near Wrexham. The development comprises:

- Stripping of soil in areas where infrastructure will be placed and where gravel access roads will be laid;
- Storing soil in soil storage mound
- Installation of solar arrays in four fields,
- Installation of electrical infrastructure including batteries and transformers.

The main findings of this Report are as follows:

- i. The only features of the development that require mitigation are the new impermeable surfaces associated with the electrical infrastructure.
- ii. The SuDS selection review leads to the recommendation of attenuation for mitigating the effects of runoff from new impermeable surfaces – this being due to the poor infiltration properties of the soils over most of the Site.
- iii. Attenuation is to be achieved using a combined swale/basin located adjacent to an existing impermeable access road. The swale/basin has been designed to accommodate inflow from the relevant portion of this road. However, in computing the allowable peak rate of runoff from the scheme, it has only been assumed that the new impermeable areas will need to be reduced to greenfield runoff.
- iv. It is demonstrated through use of a routing model and critical duration storm analysis that the proposed scheme can attenuate storms with AEP of 1%, 3.33% and 50% (annual probabilities of 1 in 100, 1 in 30 and 1 in 2) to less than the allowable rate of runoff. This includes a 20% uplift for rainfall due to climate change.
- v. Outflow from the pond is to be regulated by an orifice with diameter of 0.0325 m set at the downstream end of the outlet pipe. The inlet arrangement will feature a perforated pipe set in a geotextile and laid in a gravel filled trench to minimise the risk of any blockage.
- vi. Flow from the swale/basin will be conveyed in a shallow ditch (mostly existing) to an outfall to a riparian watercourse. This flows in turn, to the River Clywedog.
- vii. A small (15 m²) isolated transformer is too small to warrant any formal attenuation. However, this will outfall to the shallow ditch where some attenuation will occur.
- viii. Three isolated components of infrastructure (Field 2 Transformer, Customer substation and Ancillary electrical building) are too small for any attenuation system. However, they are located on the western part of the Site, where Site Investigations for an adjacent site showed reasonable infiltration rates. The rates have been used to size small infiltration basins for each component.
- ix. The SuDS components will be subject to routine maintenance, likely as part of the regular maintenance schedules for the solar farm itself.
- x. There are unlikely to be water quality problems associated with the runoff from the new surfaces. In any case, the attenuation swale/basin plus shallow ditch system will provide ample opportunity for water quality improvements within the site.

- xi. Exceedance of design events may lead to surcharging of the attenuation swale/basin. However, this may be accommodated within the design freeboard of 60 mm with excess water able to flow out via an overflow spillway.
- xii. The principal construction risk relates to the risk of waterlogging. Construction work should thus be avoided during and following prolonged rainfall.
- xiii. A Construction and Environment Management Plan (CEMP) has been provided in Appendix D; this references the proximity to the River Dee and Bala Lake SAC (Special Area of Conservation), and outlines the proposed mitigation measures.

5 References

Author	Date	Title/Description
Centre for Ecology and Hydrology.	2020	The Flood Estimation Handbook Web Service. Available from: https://fehweb.ceh.ac.uk/
CIRIA	2015	C753, The SuDS Manual.
Marshall D.C.W. and Bayliss A.C.	1994	Flood estimation for small catchments, IH Report No. 124, Institute of Hydrology, Wallingford and IN Hall, Hockin & Ellis

Appendix A Infiltration Testing

A.1 Introduction

This Appendix describes the infiltration testing that was carried out on 18th and 19th November 2020 at the Wrexham Industrial Site in support of the SuDS design. The testing was undertaken by Dr Paul Webster at five locations shown in Figure A-1. Three of these locations are at the location of the proposed car park (A, B and C) with the other two being located on the yard area (D and E).

A.2 Methodology

Infiltration testing was undertaken using a small trial pit with nominal dimensions of 0.3 m x 0.3 m x 0.3 m and were dug by hand. The pit walls were stable so there was no need to introduce any gravel for stabilisation.

The sequence of activities was as follows:

- Pits were dug on the afternoon of 18th November 2020;
- They were filled with water and measurements were made of the changing depth over time
- The four pits that had successfully drained were refilled at the end of the afternoon, but no measurements could be made due to it being dark. Pit E had not fully drained so the test was allowed to continue.
- The pits were refilled on the morning of 19th November with measurements made of the changing depth over time.

At four locations (A, B, C and D), tests were undertaken in accordance with the BRE365 Procedure i.e. with infiltration based on the results from the third filling of the trial pits. Results have still been presented for Pit E, though this is clearly not compliant with BRE365.

Water levels were recorded by “dipping” down from a reference point roughly in the middle of each pit. Photographs of each pit prior to and during testing are shown in Figure A-2.

The determination of infiltration rates requires the time taken for the pit to drain from 75% to 25% full. Since the tests at each pit were undertaken in parallel, it was not always possible to be present when these thresholds were passed. Linear interpolation has been used to estimate these thresholds from time-adjacent measurements.

A.3 The results

The results from the first test on 18th November 2020 are shown for all pits in Table A-2 and Figure A-3. The results from tests on the 19th November 2020 are shown in Table A-3 and Figure A-4. The infiltration test results are summarised in Table A-1

Table A-1: Summary of infiltration test results in units of m/s

Pit	Proposed development	Test 1	Test 2	Test 3
A	Car park	8.84E-06	overnight	3.05E-06
B	Car park	1.47E-05	overnight	7.42E-06
C	Car park	8.9E-06	overnight	3.94E-06
D	Yard area	1.91E-05	overnight	7.06E-06
E	Yard area	7.91E-07	not completed	n/a

Figure A-1: Location of infiltration test sites

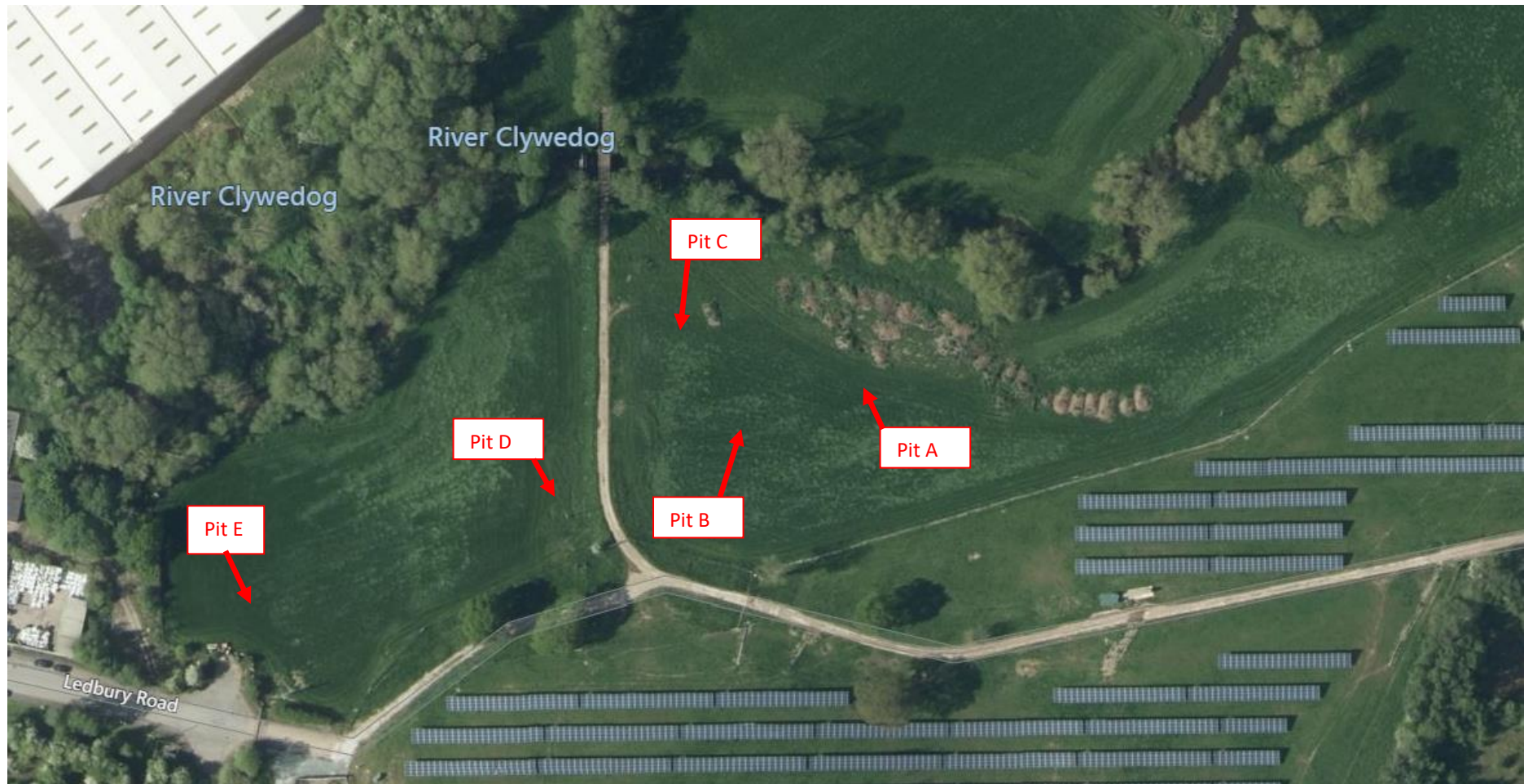


Figure A-2: The infiltration test pits

Pit A (dry)



Pit A (filled)



Pit B (dry)



Pit B (filled)



Pit C (dry)



Pit C (filled)



Pit D (dry)



Pit D (filled)



Pit E (dry)



Pit E (end of test 1)



Table A-2: Infiltration test results (Test 1 on 18th November 2020)

Pit & Trial	A1		B1		C1		D1		E1	
Length (mm)	330		310		300		300		300	
Width (mm)	300		320		269		310		310	
Start (0%)	50		75		45		40		40	
Base (100%)	290		310		295		305		320	
Range (mm)	240		235		250		265		280	
Volume (m3)	0.02376		0.023312		0.020175		0.024645		0.02604	
	50	13:48:00	105	14:08:00	85	14:39:00	70	15:27:00	95	16:40:00
	150	14:14:00	140	14:12:00	135	14:59:00	175	15:41:00	250	10:49:00
75% full (interp.)	110	14:03:36	133.75	14:11:17	107.5	14:48:00	106.25	15:31:50	110	18:25:23
	210	14:59:00	140	14:12:00	210	15:48:00	200	15:46:00	95	16:40:00
	260	15:49:00	260	14:59:00	260	16:28:00	270	16:30:00	250	10:49:00
25% full (interp.)	230	15:19:00	251.25	14:55:34	232.5	16:06:00	238.75	16:10:21	250	10:49:00
Level diff for 75% and 25% (mm)	120		117.5		125		132.5		140	
Time diff (s)	4524.0		2657.2		4680.0		2311.4		59016.8	
Vp (s) for 1 mm fall in WL	37.7		22.6		37.4		17.4		421.5	
f (m/s)	8.84E-06		1.47E-05		8.90E-06		1.91E-05		7.91E-07	
f (mm/h)	31.8		53.1		32.1		68.8		2.8	
1	50	13:48:00	75	14:03:00	45	14:30:00	40	15:25:00	40	15:45:00
2	150	14:14:00	105	14:08:00	55	14:32:00	70	15:27:00	95	16:40:00
3	210	14:59:00	140	14:12:00	85	14:39:00	175	15:41:00	250	10:49:00
4	260	15:49:00	260	14:59:00	135	14:59:00	200	15:46:00		
5					210	15:48:00	270	16:30:00		
6					260	16:28:00				

Figure A-3: Infiltration test results (Test 1 on 18th November 2020)

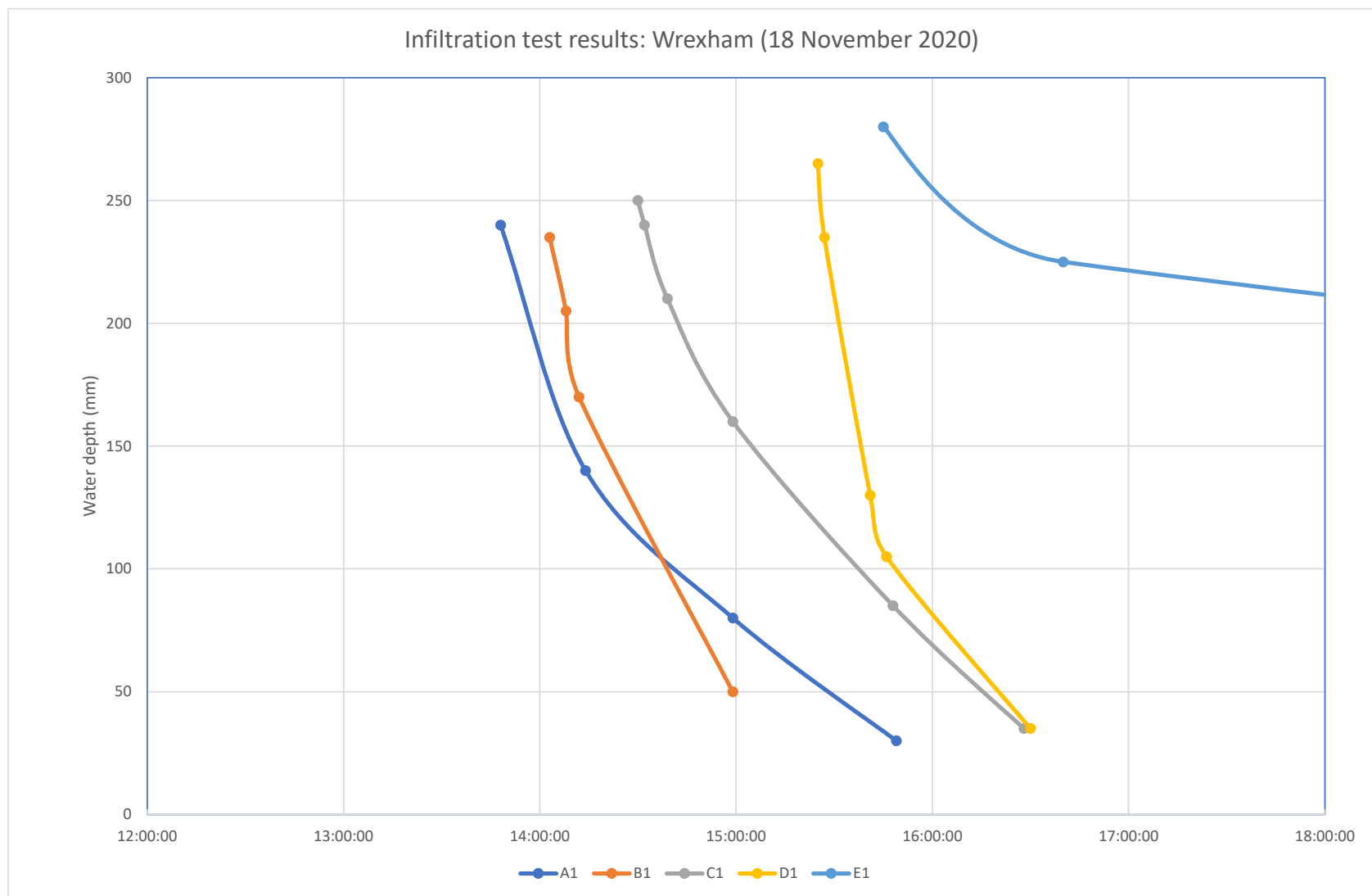
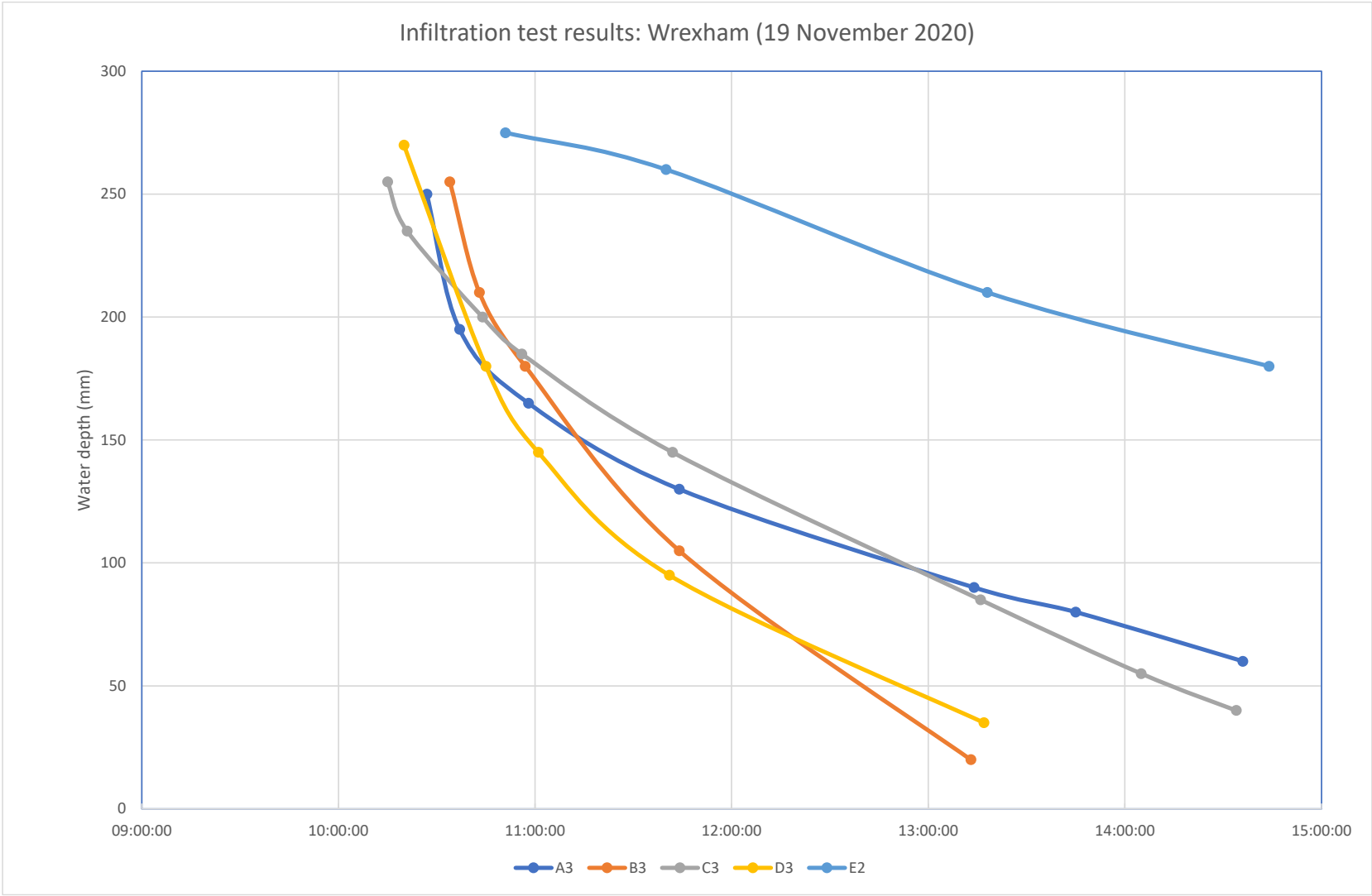


Table A-3: Infiltration test results (Tests on 19th November 2020)

Pit & Trial	A3		B3		C3		D3		E2	
Length (mm)	330		310		300		300		300	
Width (mm)	300		320		269		310		310	
Start (0%)	40		55		40		35			
Base (100%)	290		310		295		305		320	
Range (mm)	250		255		255		270		320	
Volume (m3)	0.02475		0.025296		0.020579		0.02511		0.02976	
	95	10:37:00	100	10:43:00	95	10:44:00	35	10:20:00		
	125	10:58:00	130	10:57:00	110	10:56:00	125	10:45:00		
75% full (interp.)	102.5	10:42:15	118.75	10:51:45	103.75	10:51:00	102.5	10:38:45	80	#DIV/0!
	210	13:45:00	205	11:44:00	210	13:16:00	210	11:41:00		
	230	14:36:00	290	13:13:00	240	14:05:00	270	13:17:00		
25% full (interp.)	227.5	14:29:37	246.25	12:27:11	231.25	13:50:42	237.5	12:25:00	240	#DIV/0!
Level diff for 75% and 25% (mm)	125		127.5		127.5		135		160	
Time diff (s)	13642.5		5726.5		10782.5		6375.0		#DIV/0!	
Vp (s) for 1 mm fall in WL	109.1		44.9		84.6		47.2		#DIV/0!	
f (m/s)	3.05418E-06		7.42E-06		3.94E-06		7.06E-06		#DIV/0!	
f (mm/h)	11.0		26.7		14.2		25.4		#DIV/0!	
1	40	10:27:00	55	10:34:00	40	10:15:00	35	10:20:00	45	10:51:00
2	95	10:37:00	100	10:43:00	60	10:21:00	125	10:45:00	60	11:40:00
3	125	10:58:00	130	10:57:00	95	10:44:00	160	11:01:00	110	13:18:00
4	160	11:44:00	205	11:44:00	110	10:56:00	210	11:41:00	140	14:44:00
5	200	13:14:00	290	13:13:00	150	11:42:00	270	13:17:00		
6	210	13:45:00			210	13:16:00				
7	230	14:36:00			240	14:05:00				
8					255	14:34:00				

Figure A-4: Infiltration test results (Tests on 19th November 2020)





Appendix C Full Application Form

1. Applicant Details

Applicant Name and Address

Title and Name		
Company		Innova Renewables Limited
Suffix (unit/name/number)		
Address line 1		Craven House
Address line 2		16 Northumberland Avenue
Address line 3		
Town		London
County		
Postcode		WC2N 5AP
Phone number	Mobile	
	Works	
	Home	
e-mail address		

Agent Name and Address

Title and Name		Dr Paul Webster
Company		Corylus Planning and Environmental Ltd
Suffix (unit/name/number)		
Address line 1		The Old Dairy
Address line 2		Yanworth
Address line 3		
Town		Cheltenham
County		Gloucestershire
Postcode		GL54 3LQ
Phone number	Mobile	07748 187 110

	Works	01285 721 072
	Home	
e-mail address		

Preferred contact	Applicant	Agent
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2. Site Details

A general description of site location supported by a plan specifying the construction area and the extent of the drainage system for which approval is sought MUST be submitted. Plans shall be at a scale of 1:2500. All plans MUST show the direction of North.

Name of proposed development	Wrexham Solar Development
-------------------------------------	---------------------------

Grid Reference (E/N)	338371	348465
Suffix (unit/name/number)		
Address line 1		
Address line 2		
Address line 3		
Town		
County		
Postcode		

Description of proposed development	Installation of a solar park and battery storage facility with associated infrastructure
Total application site area (Ha)	9.3 ha
Is the existing site currently developed i.e. Brownfield or is it currently undeveloped i.e. Greenfield?	Largely undeveloped but with former use as munitions factory.
Existing use	Agricultural

Proposed use	Solar farm	
Does the site cross more than one SAB area?	Yes ☐	No ☒
If "Yes", please confirm the proportionate area in each SAB below: (The main contact will be the SAB that has most of the surface water drainage system within its boundary.)		
SAB	% of Site Area	

3. Interest in the Land

What interest do you have in the land?		
Owner	Yes ☐	No ☒
Prospective Owner	Yes ☐	No ☒
Other (please provide details)	Enabling planning approval	

4. Application

Has any prior advice been sought from the SAB about this application?	Yes ☐	No ☒
If Yes, please complete the following information about the advice you were given. This will help the SAB to deal with this application more efficiently.		
Officer Name		
Reference number	n/a	Date

Details of pre-application advice received	
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Does this application relate to any other SAB application already made?	Yes ☐	No ☒
If “Yes”, please provide SAB Reference number		

Is this application part of a phased approach to development of the site, or one of multiple applications for the same site?	Yes ☐	No ☒
If “Yes”, please provide brief details		

Is this application one of two or more applications made at the same time, each setting out an alternative proposal for construction of a drainage system	Yes ☐	No ☒
If “Yes”, please provide details of other applications made at the same time (include SAB Reference number if available)		

5. Application Fee

It is recommended you contact the SAB directly to ensure the correct fee is paid with the application.

Miscellaneous	Impermeable areas and gravel	1263	m2
	Soil mound	500	m2
			m2
	Sub-total	1763	m2

Tracks	Access track length	300	m
	area of access track	900	m2
	Sub-total: road area	900	m2

SuDS	Attenuation basin	200	m2
	Ditch	110	m2
	Infiltration areas	24	
	Sub-total: swale area	334	m2

Grand total	2,997	m2
Grand total	0.30	ha
Add 10% contingency	0.33	ha
Rounded up total	0.4	ha

		Area of Land (Ha)	Fraction	Fees
Application fee		N/A	N/A	£350.00
Each 0.1ha or fraction of 0.1ha, for first 0.5ha	£70.00	0.4	0.8	£280.00
Each 0.1ha or fraction of 0.1ha, from 0.5ha up to and including 1ha	£50.00	0	0	
Each 0.1ha or fraction of 0.1ha, from 1ha up to and including 5ha	£20.00	0	0	
Each additional 0.1ha or fraction of 0.1ha above 5Ha.	£10.00			
Is the applicant a town/community council?		If yes, application fee is half the amount		No
If applicable – reduction of 50% application fee due to this being an alternative proposal made at the same time.				
If applicable – application fee adjustment due to cross-SAB area approvals needed.				
			Total Fees	£630

6. Environmental Impact Assessment (EiA) Statement

Does this application relate to a development that is the subject of an EiA application under the Town & Country Planning (Environmental Impact Assessment) (Wales) Regulations 2017(1)?	Yes ☐	No ☒
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7. Compliance with Statutory National Standards for Sustainable Drainage Systems (SuDS)

All sustainable drainage systems **MUST** comply with the [Statutory National Standards for Sustainable Drainage Systems \(SuDS\) for Wales](#). You are advised to refer to the detailed text in the Standards that relate to the information required below. The Standards are re-produced, in the [Guidance](#) to assist in completing this application form.

Standard Principles

The Principles listed below will underpin the design of surface water management schemes to meet the Statutory National Standards. Please provide a brief summary in each of the boxes below relating to each of the bulleted Standard Principles and itemised Standards 1 to 6, showing how your proposed drainage scheme complies with this statutory requirement.

Compliance with Standard Principles
My proposed surface water drainage scheme will comply in the following way/s:
Based on Section 2 (Principles) of the Sustainable Drainage Systems for Wales. - Manage water on or close to the surface and as close to the source of the runoff as possible; YES; - Treat rainfall as a valuable natural resource; n/a - Ensure pollution is prevented at source, rather than relying on the drainage system to treat or intercept it; YES - Manage rainfall to help protect people from increased flood risk, and the environment from morphological and associated ecological damage resulting from changes in flow rates, patterns and sediment movement caused by the development; YES - Take account of likely future pressures on flood risk, the environment and water resources such as climate change and urban creep; YES - Use the SuDS Management Train, using drainage components in series across a site to achieve a robust surface water management system (rather than using a single “end of pipe” feature, such as a pond, to serve the whole development); YES - Maximise the delivery of benefits for amenity and biodiversity; n/a - Seek to make the best use of available land through multifunctional usage of public spaces and the public realm; n/a

- Perform safely, reliably and effectively over the design life of the development taking into account the need for reasonable levels of maintenance; **YES**
- Avoid the need for pumping where possible; **YES** and
- Be affordable, taking into account both construction and long term maintenance costs and the additional environmental and social benefits afforded by the system. **YES**

Relevant items of supporting information (e.g. evidence, technical documents, plans and drawings etc.), as shown in [Table A](#) and [Table B](#) of this Guidance **MUST** be listed below, and all relevant material submitted.

1. Surface Water Management Plan which is the main subject of this Report.
2. Appendices to this Report as cross-referenced in this SAB Report Appendix

Standards 1 to 6

Compliance with **Standard S1 - Surface water runoff destination**

My proposed surface water drainage scheme will comply in the following way/s:

Impermeable surfaces

The only new impermeable surfaces are at 4 locations (main facility plus three isolated units as shown in Appendix B. All runoff from these surfaces will be directed to attenuation and/or infiltration basins and providing a "Priority Level 2" and "Priority Level 3" compliance. The sizing is shown in Figure 3-5 for the attenuation swale/basin and in Figure 3-8 for the infiltration basins.

The dimensions result from a critical duration analysis using the methodology in the CIRIA 753 UK SuDS Manual and the following assumptions:

- Flood Estimation Handbook point rainfall using FEH 2013.
- Annual probability of exceedance of 1% (1 in 100)
- Climate change allowance of +20% consistent with the 35-year design life
- Factor of Safety of 2.0, consistent with Table G1.1 (of Statutory Guidance)

Infiltration rates have been established from site-specific testing on an adjacent Site undertaken in accordance with BRE365 and described in Appendix A.

Runoff from solar panels

Our general experience relating to the **installation of solar panels** over many years is that there is no increase in runoff, except in specific circumstances. In general, and especially on flat sites (such as this one) runoff from solar panels is able to infiltrate into the soil either beneath the panels, or under adjacent panels. This is aided by the rainwater gap between the panels as shown in Figure 2-11. On sites with steep slopes, especially where the panels align down the gradient, increased rates of runoff may occur and require mitigation. Since this is not the case for this site, **there is no requirement for any mitigation of runoff from solar panels**. This is

supported by the observations on the existing solar site where there was no evidence of increased runoff or waterlogging under the panels (Figure 2-12).

Compound and access tracks

The compound and access tracks will be of permeable materials.

Relevant items of supporting information (e.g. evidence, technical documents, plans and drawings etc.), as shown in [Table A](#) and [Table B](#) of this Guidance **MUST** be listed below, and all relevant material submitted.

1. Drainage Strategy is part of the Surface Water Management Plan in this Report.
2. See Appendix B for locations of SuDS components
3. See Figure 3-5 for sizing of attenuation system and Figure 3-6 for plan and section of outlet device
4. See Figure 3-8 for sizing of infiltration basins

Compliance with Standard S2 - Surface water runoff hydraulic control

My proposed surface water drainage scheme will comply in the following way/s:

It is demonstrated that the attenuation system can attenuate the new development to the greenfield rate of runoff well within the Site. Further attenuation is thus likely in the c200 m ditch before discharge to the riparian watercourse.

Relevant items of supporting information (e.g. evidence, technical documents, plans and drawings etc.), as shown in [Table A](#) and [Table B](#) of this Guidance **MUST** be listed below, and all relevant material submitted.

1. Descriptions and calculations in Sections 3.2 and 3.4.1.

Compliance with Standard S3 – Water Quality

My proposed surface water drainage scheme will comply in the following way/s:

There is a very low pollution hazard level associated with this development. For the solar panels, there is not expected to be any increase in runoff due to the panels with any runoff subject to natural processes.

The impermeable surfaces are distributed across the Site. Runoff from them is expected to pose a very low pollution hazard, consistent with “residential rooves”. In any case, the runoff will be directed to attenuation or infiltration systems, designed for the 1% annual probability storm, plus allowance for climate change, with very low probability of surcharge.

Relevant items of supporting information (e.g. evidence, technical documents, plans and drawings etc.), as shown in [Table A](#) and [Table B](#) of this Guidance **MUST** be listed below, and all relevant material submitted.

1. N/a
2. .

Compliance with Standard S4 – Amenity

My proposed surface water drainage scheme will comply in the following way/s:

The proposed attenuation swale will be dry most of the time apart from during and after storms. The depression created in the grassland may create microhabitats for different plant and invertebrate species, but overall will have minor to no impact on existing habitats.

Relevant items of supporting information (e.g. evidence, technical documents, plans and drawings etc.), as shown in [Table A](#) and [Table B](#) of this Guidance **MUST** be listed below, and all relevant material submitted.

1. 258/PEA Solar Park and Battery Storage Facility at Land to the North of Maelor Gas Works, Marchwiel, Wrexham, LL13 0UN. Preliminary Ecological Appraisal

Compliance with Standard S5 – Biodiversity

My proposed surface water drainage scheme will comply in the following way/s:

See response on S4 Amenity.

Relevant items of supporting information (e.g. evidence, technical documents, plans and drawings etc.), as shown in [Table A](#) and [Table B](#) of this Guidance **MUST** be listed below, and all relevant material submitted.

1. See response on S4. Amenity.

Compliance with Standard S6 – Design of drainage for Construction and Maintenance and Structural Integrity

My proposed surface water drainage scheme will comply in the following way/s:

The most important consideration for construction is that the ground conditions are appropriate i.e. not waterlogged. Construction will be programmed to avoid parts of the site where soils may be wet and when working could exacerbate sediment runoff. A Construction and Environment Management Plan has been included as Appendix D.

Relevant items of supporting information (e.g. evidence, technical documents, plans and drawings etc.), as shown [Table A and Table B of this Guidance](#) **MUST** be listed below, and all relevant material submitted.

1. Construction Pollution Management Plan
2. Construction Environmental Management Plan as Appendix B of the Drainage Report (v3i) – this has been reviewed by NRW and a response to their comments incorporated in the latest version of the Report.

8. Assessment of Flood Risk

Is the site within an area at risk of flooding? Refer to Natural Resources Wales Development Advice maps. (Natural Resources Wales / Development and flood risk)	Yes ☒	No ☐
If the proposed development is within the area at risk of flooding, you will need to consider whether it is appropriate to submit a flood consequences assessment. (Refer to Technical Advice Note 15 (TAN15)).		

Is the site located within an area susceptible to surface water flooding? Refer to NRW Surface Water Flood Maps .	Yes ☐	No ☒
Is the site located within an area susceptible to groundwater flooding?	Yes ☐	No ☒
Is there a watercourse (as defined under Section 72 Land Drainage Act 1991) located within 20m of the proposed development?	Yes ☐	No ☒

9. Surface Water Discharge Hierarchy

Surface water drainage arrangements shall demonstrate the proposed surface water drainage complies with National SuDS Standards. As much of the runoff as possible should be discharged to each hierarchy element before a lower hierarchy element is considered. Collection and infiltration methods of drainage are required to be considered in the first instance. With reference to the hierarchy levels below, please indicate your proposed drainage arrangements.

Level	Yes	No
1. Collect for use	☐	☒

2. Infiltration	☒	☐
3. To watercourse	☒	☐
a. Is it an Ordinary Watercourse?	☐	☒
b. Is it a Main River?	☐	☒
4. To surface water sewer	☐	☒
a. Is it a Highway drain?	☐	☐
b. Is it a public sewer?	☐	☐
c. Is it a private sewer?	☐	☐
d. Other	☐	☐
5. To combined sewer	☐	☒

Has advice been sought from the asset owners?	Yes ☐	No ☒
Has advice been sought from the landowners?	Yes ☒	No ☐

10. Infiltration Assessment

Where infiltration drainage is proposed, testing should be carried out to a methodology agreed with the SAB e.g. [Infiltration Drainage - Manual of Good Practice \(CIRIA R156\)](#) and [BRE Soakaway Design \(DG 365 – 2016\)](#), and be used to inform the design, construction, maintenance, testing and assessment of infiltration systems.

Has infiltration testing been carried out?		Yes ☒	No ☐
Analysis of development Geology (including both bedrock and superficial deposits where known)		See Section 2.3 and Appendix A	
Depth to groundwater (metres)		None to depth of 1.05 m BGL using hand auger	
Borehole testing	Reference		
	Date	18	11 20

Has a Contaminated Land Assessment been undertaken?	Yes ☐	No ☒
Is the infiltration drainage proposed on contaminated land?	Yes ☐	No ☒

Infiltration test result	Tests at 5 locations with results in Section A.3 and 2.3
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11. Non-performance Bond, Adoption, Operation & Maintenance

What are your proposals regarding cost of works, adoption and maintenance of the SuDS scheme?

Non-performance Bond – Estimated cost of work	
Adoption (including land agreements etc)	
Funded Maintenance Plan for the lifetime of the development	

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12. SuDS Scheme Application Checklist

Please complete the following checklist and make sure you have read the Guidance on Making SuDS Applications for SAB Approval , the Guidance on completing the Full Application Form , and provided all the necessary information in support of your application:	
Correct Full Application fee.	Yes ☐
Completed, signed and dated Full Application form.	Yes ☐
Plan/s specifying the construction area and the extent of the drainage system for which approval is sought. All plan/s shall be at a scale of 1:2500 and MUST show the direction of North.	Yes ☐
Taken account of SAB Guidance on technical information to be submitted to enable SAB to assess your Full Application.	Yes ☐

13. Declaration

I/ we hereby apply for SuDS Approval as described in this form and the accompanying plans/drawings and additional information. I confirm that I have read and complied with the National SuDS Standards and, to the best of my knowledge, any facts stated are true and accurate and any opinions given are the genuine opinions of the persons giving them.

This form has been completed using evidence from the Flood Consequences Assessment where applicable, surface water drainage strategy and site plans and associated documents.

This form has been completed using accurate information. It can be used as a summary of the detailed surface water drainage proposals on this site, and clearly shows that these drainage proposals conform to the National SuDS Standards for Wales.

Form completed by	Dr P Webster
Signature	<i>P Webster</i>
Qualification of person responsible for signing off this application	BSc, DIC, MSc, PhD, FCIWEM, C.WEM
Company	Corylus Planning and Environmental Ltd
On behalf of (Client's details)	Innova Renewables Ltd
Date	27 th April 2021

Disclaimer

Information provided on this form and in supporting documents may be published on the SABs SuDS register and website and be made publicly available.

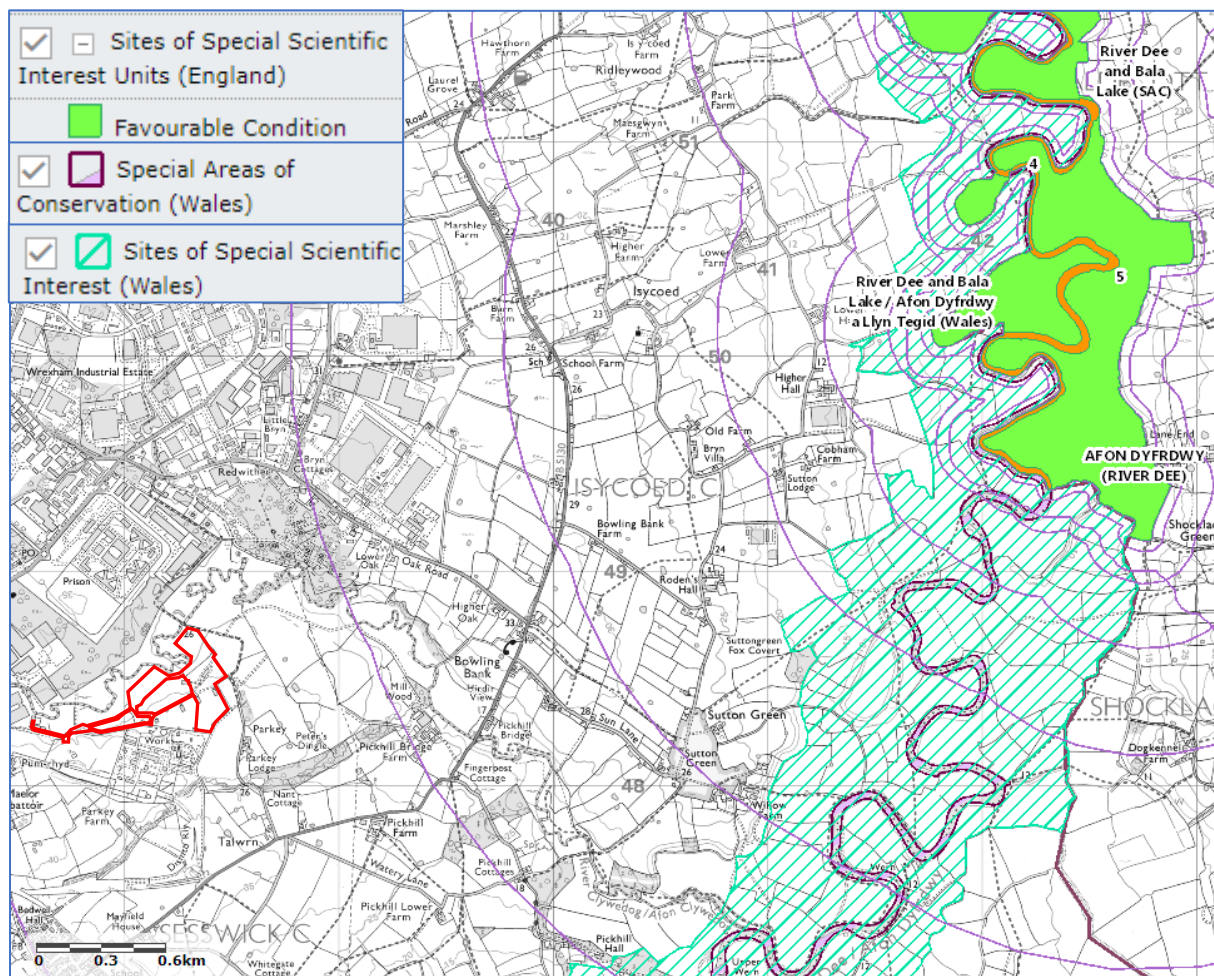
Appendix D Construction and Environment Management Plan

D.1 Introduction

This Appendix provides a CEMP for the proposed solar farm. The specific context for the CEMP follows from the designations in the vicinity of the Site. An approximate site boundary has been superimposed on a MAGIC map extract in Figure D-1. Since the River Clywedog, which flows adjacent to the Site is a tributary of the River Dee, there is a potential pathway from the Site that may impact upon the River Dee and Bala Lake SAC (Special Area of Conservation), and SSSI in England and Wales.

In view of the potential pathways from Site to these areas, consideration is clearly required of the potential impacts and any mitigation.

Figure D-1: Location of SAC & SSSI in relation to Site



<https://magic.defra.gov.uk/magicmap.aspx>

D.2 Potential Pollution Pathways to Watercourses and Protection

The watercourses relevant to the Site are described in Section 2 and Section 3 of the Main Report. They comprise:

- The River Clywedog flowing broadly eastwards along the northern boundary; and
- A small riparian watercourse (ditch) flowing intermittently along the north-east boundary and outfalling to the River Clywedog.

The **Potential Pollution Pathways** have been annotated on Figure D-2. They have been drawn mainly on the basis of topography and as such, most arrows are orthogonal to the general contours i.e. downslope. Some shallow swales were identified during the site visits, notably parallel to an internal access route (see for example Figure 3-3 in Field 1B).

No arrows are shown for some parts of the development; these are generally flat areas where surface flows are unlikely. These include the flood plain areas e.g. Field 1A in Figure 2-3a and Field 2 in Figure 2-6. However, Field 1C is not part of the floodplain and is also relatively flat (Figure 2-5).

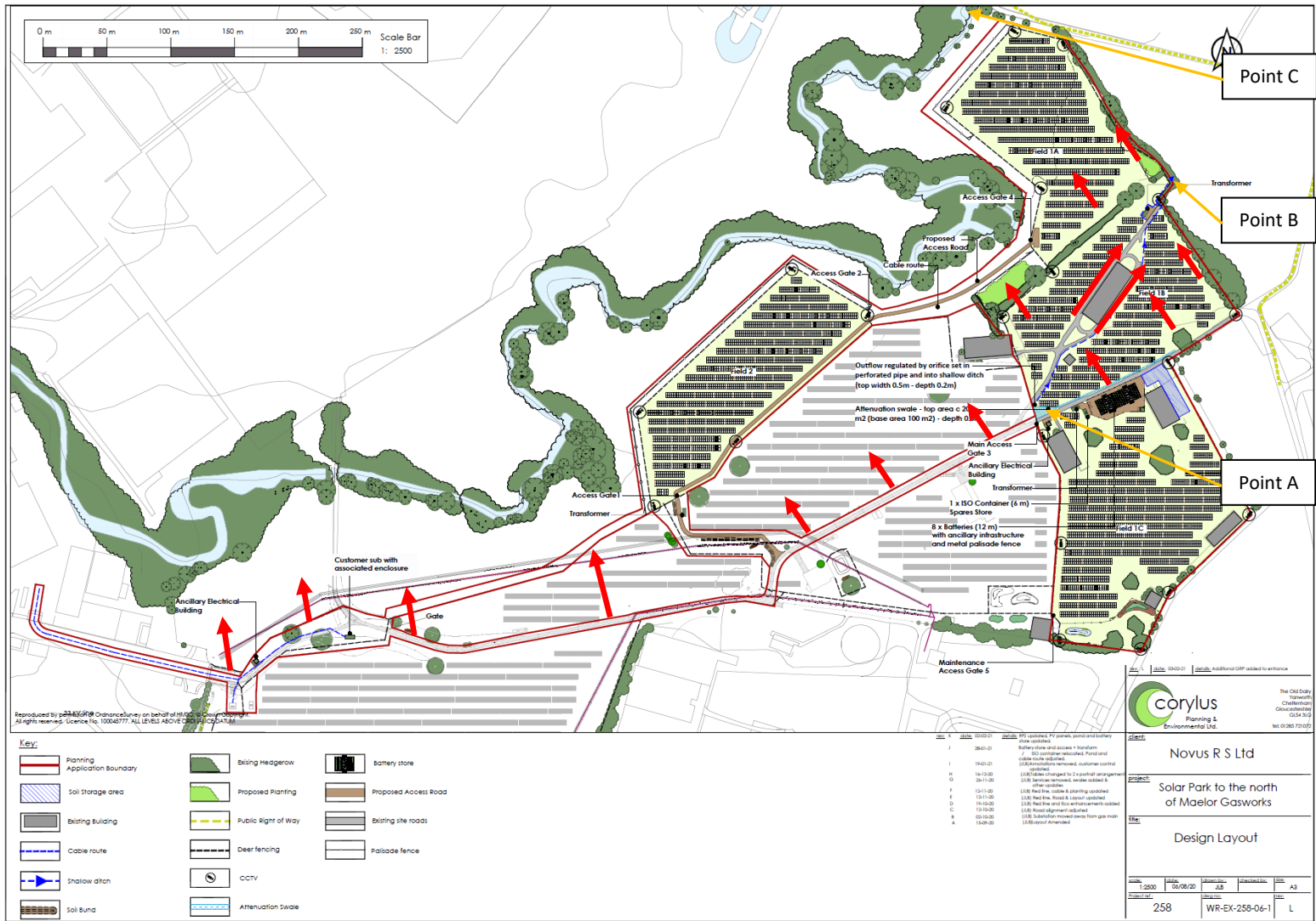
The mitigation measures for drainage are outlined in Sections 3.3 and 3.4 of the Main Report, comprising an attenuation swale adjacent to the largest area of hardstanding. The outlet from the attenuation swale will exploit existing drainage routes with treatment stages outlined Section 3.5. Other isolated components of infrastructure will drain to infiltration areas adjacent to the source of runoff. It is not considered that any further mitigation is needed for other features of the completed development; this being based on the observations from the adjacent solar site which provides a helpful analogue.

The principal risk during construction relates to ground conditions. The physical nature of the construction is considered to be very modest. Specifically, this will entail the installation of pile supports for the solar arrays and the excavation of shallow cable trenches. Such activity can be undertaken with small vehicles. The topography and soils mean that parts of the site may be prone to waterlogging during winter months. The construction should avoid working during or following periods of prolonged rainfall.

The drainage features should be constructed **prior to any other works**. This will both provide the mitigation for storms during the construction period and ensure that there is no possible conflict with the land required for the SuDS components.

The stripped soil should be placed with minimal compaction in the soil storage area. Whilst regrowth of grass is likely, given the source material, reseeding should be undertaken of bare patches to minimise runoff of water and silt from the soil mound. The soil mound is located on a relatively flat part of the Site which will help to mitigate any runoff (water and silt) from the soil mound.

Figure D-2: Potential Pollution Pathways



D.3 Construction Method Statement / Construction Health and safety plan

(a) General

Prior to works beginning on site, a Construction Method Statement would be put in place to govern activity on site. Included within this will be information on the proper transportation, handling and storage of all materials, incident response plans and reporting instructions. Construction best practice will be applied and a site-specific environmental checklist will be completed prior to any works commencing on site.

(b) Construction Plant

All machinery comes with a maintenance certificate / condition report showing it is fit for service. There are also daily condition checks to ensure machinery is suitable for use. Any road going vehicle coming on site for deliveries or bringing personnel will have an MoT.

Site personnel will be aware of the Incident response plan for the site. Spill kits are available on site and any incidents will be reported to site management and to the relevant authority if necessary.

The risk of leaks or spill from machinery on site is low. There may, however be a requirement to have oil or fuel available on site for machinery refuelling, these will be stored in bunded tanks to prevent any spillage into the ground and any refuelling will take place with a drip tray. (See full detail below).

(c) Oil, Fuel and Liquid Chemical Storage

The storage of all oil/fuel containers with a capacity of 200 l or more will comply with the requirements of the Control of Pollution (Oil Storage) regulations. Generally, this means that:

- Oil drums are to be stored on proprietary secondary containment systems that will contain 110% of the contents of the largest container, or 25% of the total, whichever is greater. These are to be protected to minimise the ingress of rainwater and secured against unauthorised discharge.
- All bulk storage tanks are to be integrally bunded proprietary tanks. The tanks are to be located within the compound area of the site, away from general traffic movements and a minimum of 10m from any surface water drain, stream or other water course and secured against unauthorised discharge.
- Only authorised personnel will be issued with a key to the bulk storage tanks for refuelling machinery. When refuelling, the operator must remain in attendance at all times.
- All personnel will be inducted into the Site Incidence Response Plan and the Site Manager is to be notified of all spillages, however minor.
- Spill kit(s) will be available on site and site personnel informed of its location during induction.
- Oils and other chemicals, in containers with a capacity of less than 200ltrs, will be stored within a locked store on either on impervious floor or drip trays. Only authorised personnel will be issued with a key to this store.

- The location of any fuel/oil storage areas and procedures must be agreed with Site Management prior to any deliveries. No storage will be permitted within 10 m of any stream or surface water drains.

D.4 Monitoring of Water Quality

With the limited nature of the construction activity and the precautionary measures that are proposed, it is not considered necessary to undertake any formal monitoring of water quality. However, since the only viable source of pollution would be from surface runoff into adjacent watercourses, then a regular programme of **daily observation** should be undertaken. Since the background water quality is good (i.e. clear water), then the impacts of any pollution should be evident from turbidity and cloudiness in the water being observed.

The key locations where observations would be made would be at the points labelled A to C in Figure D-2. A proforma for recording observations is offered in Table D-1. It would be incumbent upon the construction team to immediately identify the source of any pollution and to take such action as necessary to stop it. The incident should also be reported to NRW via the Hotline.

Report an environmental incident

To **report an environmental incident**, call **0300 065 3000** (option 1) 24 hours a day, seven days a week. By calling us, we are able to respond to environmental issues quickly.

Find out about call charges at Gov.uk

Table D-1: Proforma for recording surface water quality

Date	
Time	
Observer	
Weather Conditions	

A – attenuation swale	
Observation	Action
B – outfall to riparian ditch	
Observation	Action
C – River Clywedog at downstream boundary	
Observation	Action

Signed:

D.5 Operational Considerations

(a) Battery Stores

Li-ion batteries have been proposed, and the chemical makeup and design makes discharge/leak of the electrolyte very low risk. Individual battery cell architecture comprises the anode, cathode and electrolyte all wrapped up in sealed metal casings. Many individual cells are arranged into a module with cooling and management systems all in a further housing. The modules are secured in racking systems within adapted 40ft metal shipping containers, therefore risk of discharge into the ground is very low.

There is no greater risk anticipated in the installation phase. Battery containers arrive on site with the modules already secured inside ready for connection, so there is no storage or handling of modules.

(b) Cleaning of panels

Panels require occasional cleaning. This is done with de-ionised water with no harmful impact upon the environment.

D.6 Summary

This Appendix provides a CEMP for the proposed construction of a solar farm and associated cable adjacent to an existing solar farm north of the Maelor gas works near Wrexham. The main findings are as follows:

- i. The sensitivity of the scheme is triggered by the proximity to areas designated as SSSI and SAC associated with the River Dee.
- ii. There are two hydrological receptors comprising the River Clywedog and a riparian watercourse.
- iii. The theoretical pollution pathways follow the topographic gradient within and away from the Site. Modified in part by shallow swales within the Site. Furthermore, mitigation measures are proposed to mitigate runoff of water and silt from areas of hardstanding.
- iv. A Construction Method Statement / Construction Health and safety plan will be prepared, as outlined in Section D.3 and dealing with the Construction plant and the storage of oils and chemicals on the Site.
- v. Construction of the required solar arrays requires relatively small vehicles and intervention. However, the construction should avoid periods when the fields may be waterlogged in winter.
- vi. Whilst formal monitoring of water quality is not required, a programme of daily inspection at three specific locations will be undertaken.



Planning

Landscape

Architecture

Hydrology

Ecology