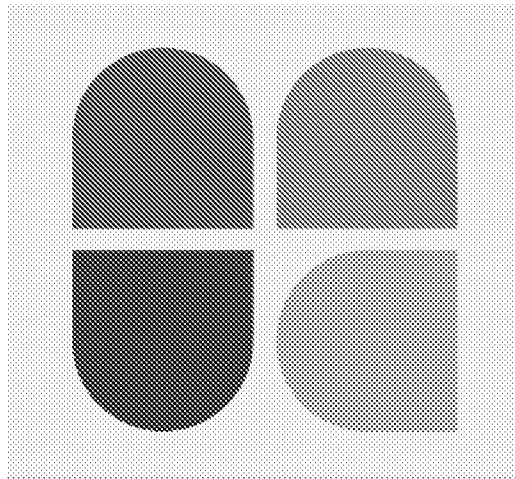




BRIGHT PLAN CIVILS

**LIDSEY LODGE FARM, SACK LANE,
LIDSEY PO22 9PE**

PROPOSED RESIDENTIAL DEVELOPMENT

Flood Risk Assessment and Conceptual
Drainage Strategy

Prepared on Behalf of

Melanie Jenkins

D1922/FRA3.0

04 June 2021

DOCUMENT CONTROL

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 Proposed Residential Development

 Document: Flood Risk Assessment and Conceptual Drainage Strategy

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Appendix B Topographical Survey
Appendix C Geotechnical Information
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Appendix E Environment Agency Product 4 Response
Appendix F Drainage Calculations

1 INTRODUCTION

1.1 Background

- 1.1.1 Bright Plan Civils (BPC) is instructed by Melanie Jenkins to prepare a site-specific Flood Risk Assessment (FRA) and Drainage Strategy to support a planning application for a proposed residential development at Lidsey Lodge Farm, Sack Lane, Lidsey.
- 1.1.2 This FRA and Drainage Strategy has been undertaken in accordance with Planning Practice Guidance: Flood Risk and Coastal Change and National Planning Policy Framework Section 14.
- 1.1.3 The proposed development will involve the construction of 8 residential properties - as demonstrated within the preliminary site layout, contained within **Appendix A** of this report.
- 1.1.4 In preparing this report, BPC has referred to the following documents and information:
- Environment Agency Flood Maps for Planning
 - Long Term Flood Risk Information; Flood Risk Maps
 - Local Authorities Strategic Flood Risk Assessment
 - Southern Water and Local Authority Drainage Records
 - Site-specific Environmental Investigation Report
 - British Geological Survey & Records
- 1.1.5 This document has been prepared to assess if the proposed development is suitable for the site and confirms if mitigation is required to ensure that flood risk is not increased, and that the proposed development remains safe during its design life.
- 1.1.6 This report has been prepared for the benefit of the named Client only.

1.2 Site Location and Description

- 1.2.1 The site is an existing agricultural yard with several large storage barns.
- 1.2.2 The site has a total area of 8200 m² (0.82 Ha) – as shown on Drawing **100**.
- 1.2.3 A topographical survey of the site has been undertaken by Medlams Surveys Limited. A copy of this survey is included in **Appendix B** of this report.
- 1.2.4 The topographical survey shows that the site is between 4.30m AOD along the entrance route, to 2.25m AOD along the eastern boundary, and 1.50m AOD within the ditches along the northeast boundary and southeast boundary. The site generally falls gently eastwards. This influences the existing overland flow routes – as detailed in Drawing **101**.

- 1.2.5 The existing site is predominantly hardstanding, as seen in Drawing **102**. There is no known existing positive drainage infrastructure. Runoff from the concrete and hardstanding areas and the existing storage partially by infiltration and also overland to the boundary ditches.

1.3 Ground Conditions

- 1.3.1 A site-specific geotechnical investigation was provided by Leap Environmental Limited in February 2021, with extracts included in **Appendix C** of this report.
- 1.3.2 The encountered ground conditions consisted of:
- Concrete - 0.0-0.2 mbgl (metres below ground level)
 - Made Ground – 0.2-0.9 mbgl
 - Gravelly Sandy CLAY – 0.3-4.0 mbgl
 - CHALK – 0.85-4.45 mbgl
- 1.3.3 Chalk was found across all boreholes other than WS4, with varying depth between 0.85-4.0mbgl.
- 1.3.4 Soakage testing was undertaken within boreholes WS1 and WS2, however water level rose in the test within borehole WS1 over 270 minutes, and water level only fell from 1.00mbgl to 1.05mbgl over 320 minutes within borehole WS2. The results are not compliant with BRE365 requirements since water level did not fall to 25% of maximum depth, and no infiltration rate could be calculated.
- 1.3.5 The results show that infiltration is not a feasible method of surface water discharge at the site.
- 1.3.6 In addition to the site-specific investigation, reference has been made to the British Geological Survey (BGS) website.
- 1.3.7 The BGS geology viewer states that the bedrock geology is likely to consist of 'Lewes Nodular Chalk Formation, Seaford Chalk Formation, Newhaven Chalk Formation, Culver Chalk Formation and Portsdown Chalk Formation (undifferentiated) - Chalk', as seen in **Figure 1**.

Bedrock geology

- LONDON CLAY FORMATION - CLAY SILT AND SAND
- LAMBETH GROUP - CLAY SILT AND SAND
- LEWES NODULAR CHALK FORMATION, SEAFORD CHALK FORMATION, NEWHAVEN CHALK FORMATION, CULVER CHALK FORMATION AND PORTSDOWN CHALK FORMATION (UNDIFFERENTIATED) - CHALK

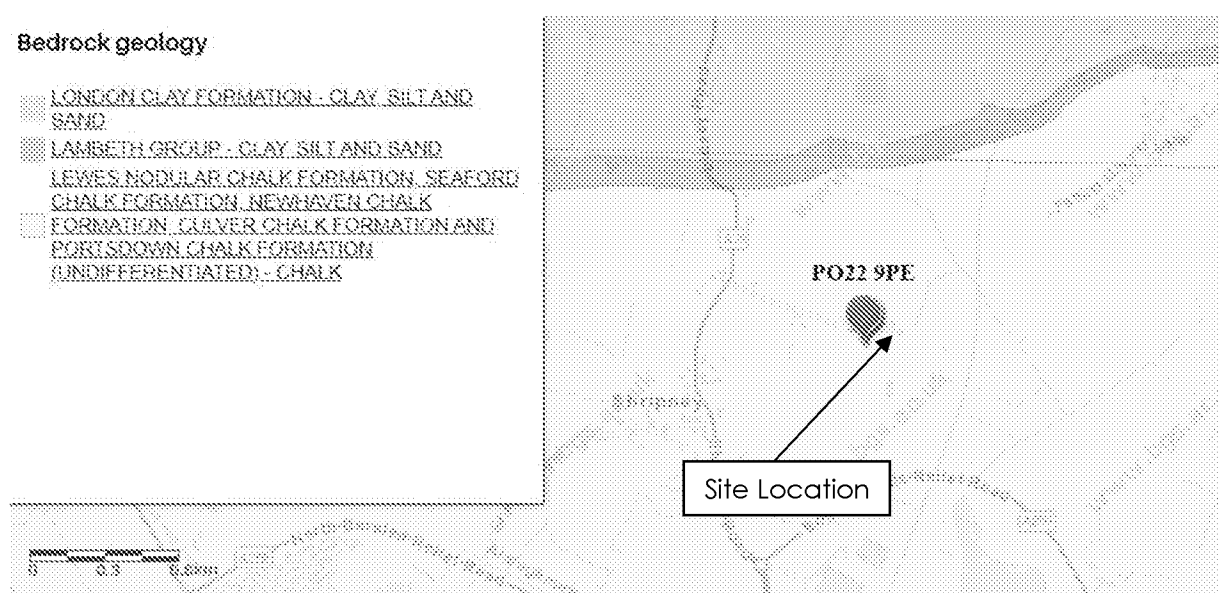


Figure 1. BGS website Bedrock geology

- 1.3.8 Superficial Deposits located at the site area are recorded as 'River Terrace Deposits (undifferentiated) - Sand, Silt and Clay', with 'Raised Marine Deposits - Clay, Silt, Sand and Gravel' to the east of the site, as seen in **Figure 2**.

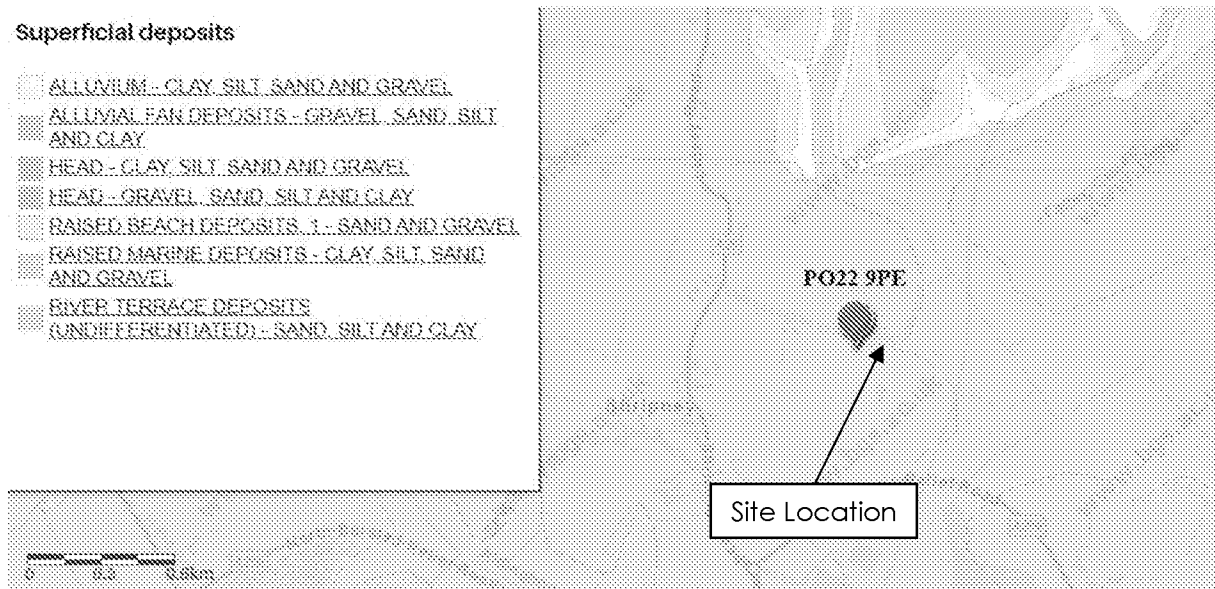


Figure 2. BGS website superficial deposits

- 1.3.9 Historic borehole records from the Single Onshore Boreholes Index (SOBI) on the BGS website have also been reviewed, as depicted in **Figure 3**.

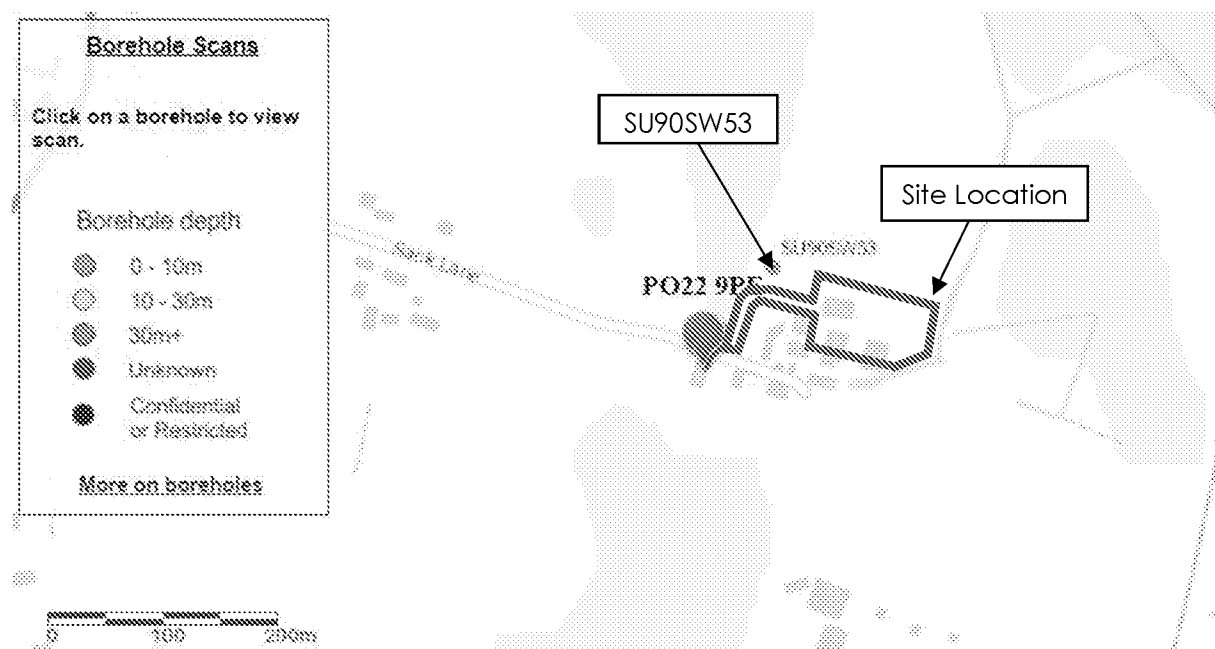


Figure 3. BGS website borehole locations

- 1.3.10 The borehole is located at Lidsey Lodge, and found the following underlying soil profile:

- Soil - 0.0-0.3 mbgl (metres below ground level)
- Brickearth Clay – 0.3-2.0 mbgl
- Raised Beach Deposits ('Very clayey' sandy gravel) – 2.0-3.5 mbgl
- Silt – 3.5-4.1 mbgl

1.3.11 A copy of the BGS records reviewed can be found within **Appendix C** of this report.

1.4 Groundwater

1.4.1 Boreholes excavated at the site by Leap Environmental Limited encountered groundwater during the site investigation, and groundwater monitoring has been undertaken from 18th December 2020 to 26th March 2021. Groundwater levels recorded are shown in **Table 1**.

Monitoring Well	Depth to groundwater (mbgl)					
	18/12/20	06/01/21	29/01/21	12/02/21	26/02/21	26/03/21
WS3	1.31	1.02	0.75	0.87	1.17	1.48
WS4	1.24	0.98	0.98	0.90	1.16	1.49

Table 1: Groundwater Monitoring Results

1.4.2 The BGS borehole had a recorded surface level of 3.4mAOD and a depth of 4.1 mbgl, with groundwater not struck. A copy of the BGS records reviewed can be found within **Appendix C** of this report.

1.4.3 Following consultation with West Sussex County Council, it has been confirmed that the site is situated within an area that is at high-risk of groundwater emergence, as seen in **Figure 4**. Correspondence can be found within **Appendix D**.

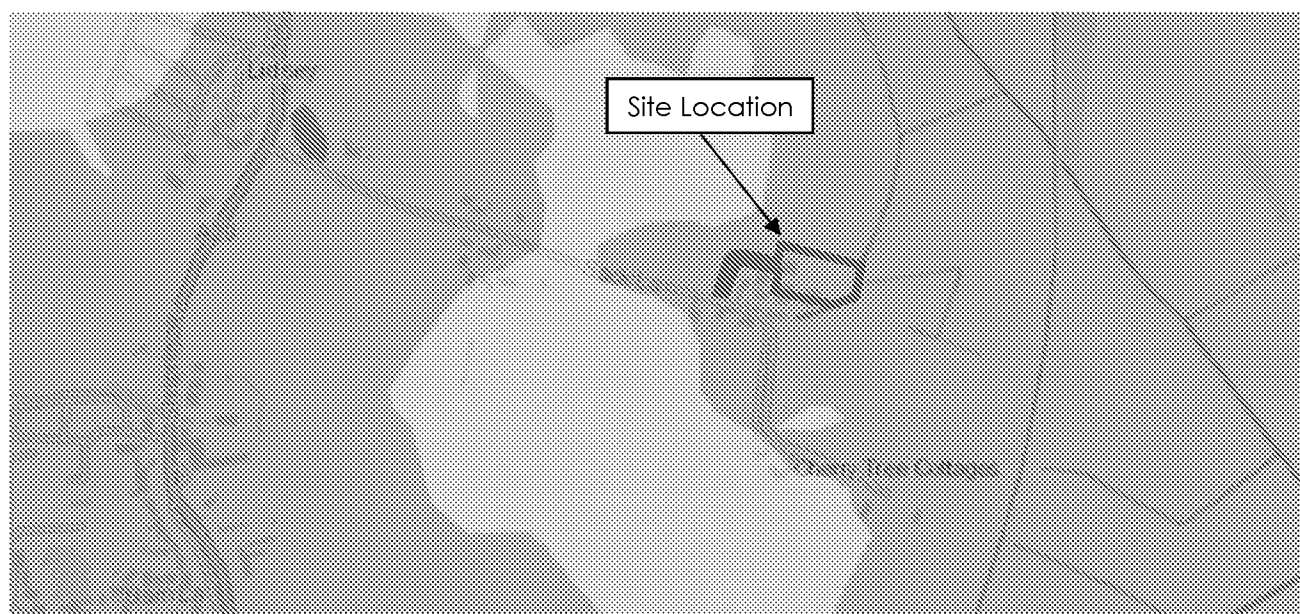


Figure 4. WSCC Groundwater Flood Risk Mapping

1.4.4 In addition, consultation with Arun District Council identified the site as having high groundwater and poor infiltration potential.

1.4.5 Mapping managed by MAGIC (magic.defra.gov.uk) provides geographic information concerning the natural environment from across government. This mapping tool has been referred to in order to confirm whether the site is located within either any groundwater source protection zones or groundwater vulnerability zones.

1.4.6 As seen in **Figure 5**, the site is situated within:

- 'Secondary A' Superficial Deposits Aquifer – superficial deposits that exhibits variable permeability and/or provide a variable level of water storage. The deposits may support water supply and/or river base flow on a local scale.
- 'Principal' Bedrock Aquifer - bedrock geology that exhibits typically high permeability and/or provides a high level of water storage. The bedrock may support water supply and/or river base flow on a strategic scale.



Figure 5. DEFRA Aquifer Designation Map

1.4.7 The Groundwater Vulnerability Maps show the vulnerability of groundwater to a pollutant discharged at ground level. The Groundwater Vulnerability Map (**Figure 6**) confirms that the site falls within a 'Medium' groundwater vulnerability zone. The map does also however indicate soluble rock risk.



Figure 6. DEFRA Groundwater Vulnerability Map

1.5 Existing Drainage

1.5.1 The site falls within the administration of Arun District Council (ADC) and West Sussex County Council (WSCC) who have been consulted in view of the existing drainage infrastructure local to the site.

1.5.2 Surface Water:

- The local Water Authority is Southern Water, who provide sewerage services within the area. The public sewer records service demonstrates that there are no Southern Water public surface water sewers located in the area of the site or along Sack Lane.
- There are ditches along the northern, eastern, and south-eastern boundaries of the site. These are noted to be shallow and of 500-1000mm depth, however not all ditch profiles are confirmed by the topographic survey information. Mapping shows that these connect into the Lidsey Rife located approximately 300 metres to the north east of the site.
- The nearest Main River is a tributary of the Lidsey Rife, which runs south-easterly from Eastergate, and runs past 300 metres northeast of the site. The site boundary ditches discharge into this Main River.
- Using the HR Wallingford online calculator, Greenfield runoff rate (Qbar) has been calculated to be **1.6 l/s** (Q30 = 3.7 l/s, Q100 = 5.1 l/s).
- As the site is developed however, the existing runoff is expected to be approximately **92.9 l/s** (based on a flat rainfall rate of 50mm/hr).

1.5.3 Foul Water:

- The local Water Authority is Southern Water, who provide sewerage services within the area. The public sewer records service demonstrates that there are no Southern Water public foul water sewers located in the area of the site or along Sack Lane.
- Foul drainage of neighbouring properties is unknown, however a recent development to the south of the site at Sack Lane Dairy has utilised a sewage treatment plant and discharge to the ordinary watercourse.

1.5.4 Highway Drainage:

- Consultation with WSCC and ADC did not identify any highway drainage infrastructure. Review of online mapping demonstrates that Sack Lane drains via over-the-edge runoff.

2 PROBABILITY

2.1 Sources of Information

- 2.1.1 The NPPF requires that all sources of flooding are considered being Tidal, Fluvial, Pluvial, Groundwater, Sewers and Man-made reservoirs/canals.
- 2.1.2 The likelihood of the site flooding has been established by reviewing the following information:
- Environment Agency Flood Maps for Planning
 - Long Term Flood Risk Assessment Surface Water Flood Risk Maps
 - Long Term Flood Risk Assessment Reservoir Flood Risk Maps
 - Local Authorities Strategic Flood Risk Assessment
 - Consultation with Local Authority/Lead Local Flood Authority

2.2 Flood Maps and Modelling

- 2.2.1 The Environment Agency's Product 4 Response provided flood maps for rivers, sea and surface water as seen in **Appendix E**.
- 2.2.2 The Product 4 shows the site location within Flood Zone 1. The northeast, east and southeast boundaries within Flood Zone 2 and 3.
- 2.2.3 The site is not protected from any formal fluvial flood defences; however the area is defended by coastal defences. The area is drained to the sea via the Felpham pumping station when the gravity outfalls of the Aldingbourne Rife are tidally locked.
- 2.2.4 The Fluvial model used was the Aldingbourne Modelling Study (Defended Only) which was completed by JBA Consulting in 2015, plus updated climate change allowances (2016). Levels are shown in **Table 2**.

Node Ref	Modelled Flood Levels (m AOD)							
	Fluvial Undefended Levels				Fluvial Defended Levels			
	1%	1% + 45% CC	1% + 105% CC	0.1%	1%	1% + 45% CC	1% + 105% CC	0.1%
1	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-
3	-	-	2.20	-	2.08	2.15	2.20	2.18
4	-	-	-	-	-	-	-	-

Table 2: Environment Agency Product 4 Fluvial Flood Levels

- 2.2.5 As detailed in Drawing **D1922-101** and **D1922-200**, existing site levels within the development area are between 2.25mAOD and 4.20mAOD. Comparison to the predicted fluvial flood levels and the existing site elevations confirm that the site is elevated above fluvial flood levels up to the modelled events in undefended and defended scenarios. Areas below the flood levels to the south and east of the site are to be returned to the environment, also forming a landscape / ecology buffer zone.
- 2.2.6 The Tidal model used was the River Arun to East Head Coastal Modelling (2D) which was completed by JBA Consulting in 2016. Levels are shown in **Table 3**.

Node Ref	Modelled Flood Levels (m AOD)							
	Tidal Undefended Levels				Tidal Defended Levels			
	0.5%	0.5% (2070)	0.5% (2115)	0.1%	0.5%	0.5% (2070)	0.5% (2115)	0.1%
1	-	-	3.61	-	-	-	-	-
2	-	2.66	3.61	-	-	-	-	-
3	1.97	2.66	3.61	2.14	-	-	-	-
4	-	-	3.61	-	-	-	-	-

Table 3: Environment Agency Product 4 Tidal Flood Levels

- 2.2.7 In conjunction with the Topographic Survey, Table 3 demonstrates that the site not at risk of flooding from rivers or the sea.
- 2.2.8 However, as a result of climate change and sea level rise, the site is at residual risk of tidal flooding in a 0.5% AEP scenario in the 2115 epoch.
- 2.2.9 The Environment Agency's on-line Flood Maps for Planning (rivers and sea), as seen in Figure 6, shows that the site is located within Flood Zone 1. Flood Zone 1 is defined as land having less than a 1 in 1,000 annual probability of river or sea flooding, as seen in **Table 4**.
- 2.2.10 The northeast, east and southeast boundaries are within Flood Zone 2 and 3.
- 2.2.11 The flood zones are also confirmed by information and mapping obtained following consultation, and is consistent within other flood risk mapping reviewed.

Flood Zone	Definition
Zone 1 Low Probability	Land having a less than 1 in 1,000 annual probability of river or sea flooding. (Shown as 'clear' on the Flood Map – all land outside Zones 2 and 3)
Zone 2 Medium Probability	Land having between a 1 in 100 and 1 in 1,000 annual probability of river flooding; or land having between a 1 in 200 and 1 in 1,000 annual probability of sea flooding. (Land shown in light blue on the Flood Map)
Zone 3a High Probability	Land having a 1 in 100 or greater annual probability of river flooding; or Land having a 1 in 200 or greater annual probability of sea flooding. (Land shown in dark blue on the Flood Map)
Zone 3b The Functional Floodplain	This zone comprises land where water has to flow or be stored in times of flood. Local planning authorities should identify in their Strategic Flood Risk Assessments areas of functional floodplain and its boundaries accordingly, in agreement with the Environment Agency. (Not separately distinguished from Zone 3a on the Flood Map)

Table 4: Environment Agency Flood Zone Definitions

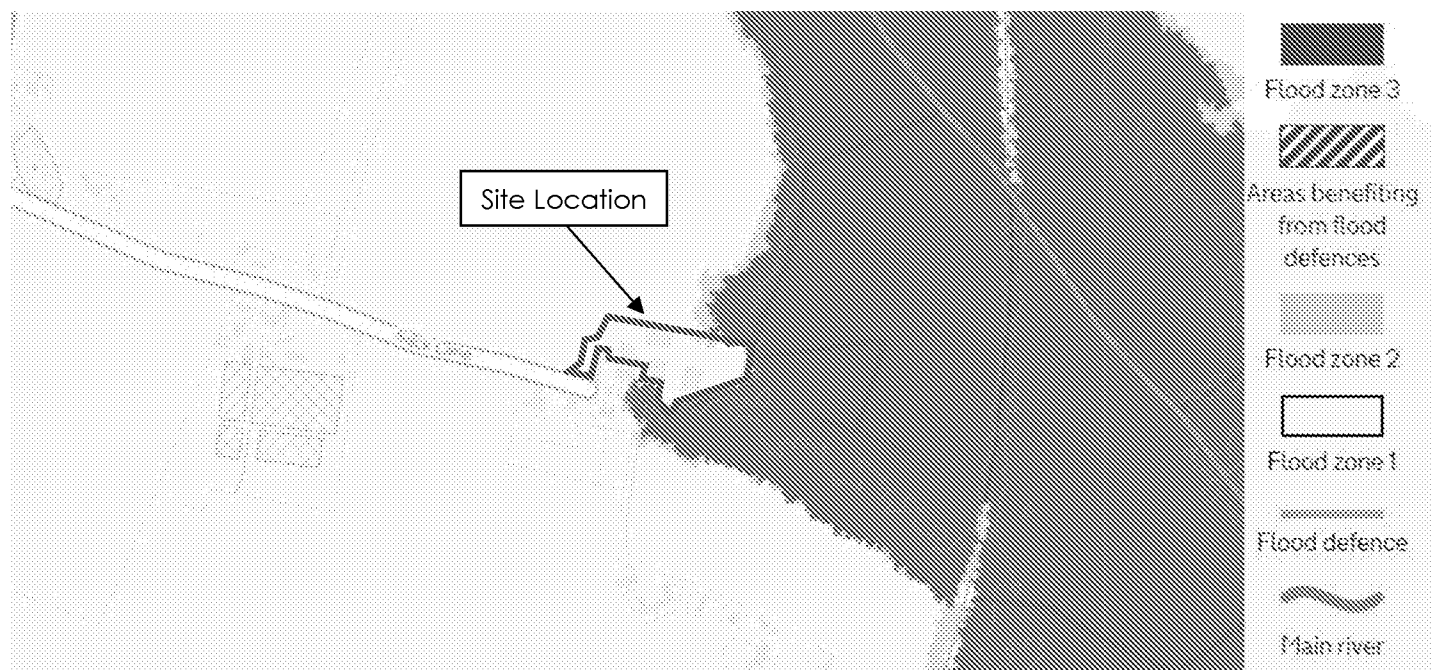
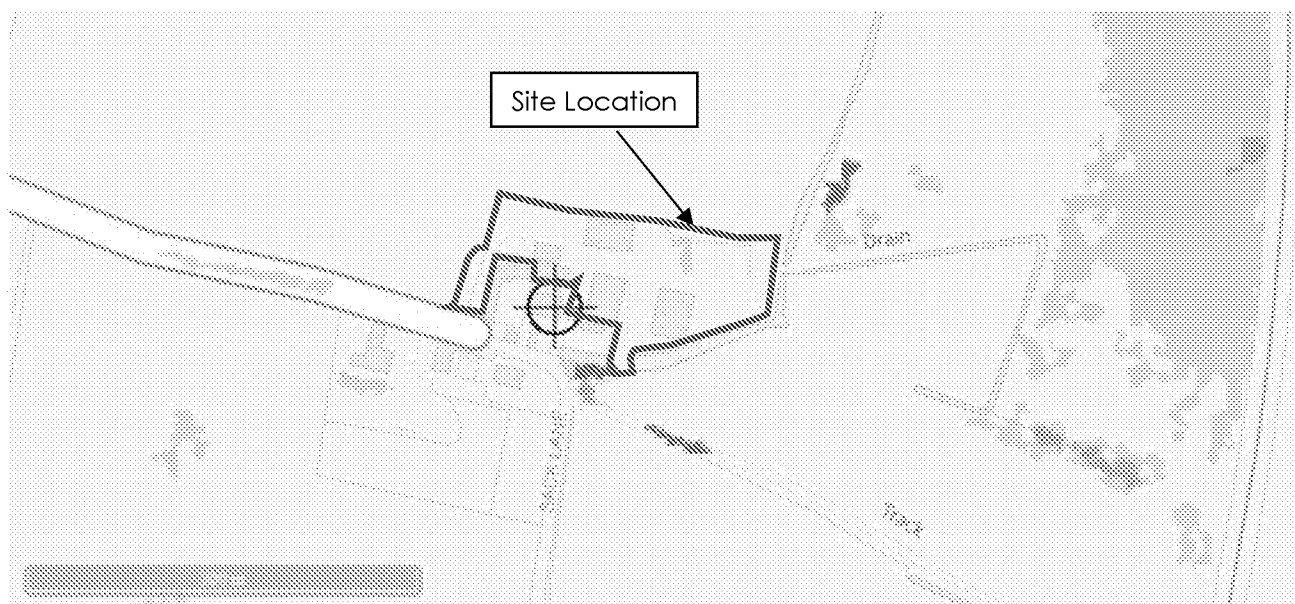


Figure 6. Flood Map for Planning (rivers and the sea)

2.2.12 **Figure 7** shows that the site at very low to low of surface water flooding. Mapping shows that flood depths are not expected to exceed 300mm depth in any scenario.



Extent of flooding from surface water

High Medium Low Very low Location you selected

Figure 7. Long Term Flood Risk Map; Flood risk from surface water

2.2.13 **Figure 8** shows that the site is not at risk of flooding from reservoirs.



2.3 Strategic Flood Risk Assessment

2.3.1 The Arun District Council (ADC) SFRA identified the site area:

- is not within Flood Zone 3a, however due to climate change is expected to be within Flood Zone 3a in year/epoch 2111.
- Partially within a Flood Warning Area, used to warn people of expected flooding.
- No localised defences in the site area, however noted to be protected by sea defences to the south.

2.3.2 The ADC SFRA also noted the findings of the Arun Strategic Surface Water Management Study (2016), which noted that high groundwater levels limited the use of deep soakaways, and although some groundwater may be possible at a shallow depth through the base of swales, SuDS in these areas should primarily focus on attenuation features discharging at a controlled rate to local watercourses.

2.3.3 Consultation with ADC also confirmed that the site area has high groundwater and poor infiltration potential, and that there is no known mains drainage along Sack Lane. Lands drainage records from AD show land drainage from the properties to the south near Winters Barn, with several existing manholes/connections, discharging into the watercourse to the south east of the site.

2.3.4 Consultation with West Sussex County Council (WSCC) noted that current JBA Groundwater Flood Risk mapping the area is at 'High' risk of groundwater flood, with groundwater either very near or within 0.025m of the ground surface.

2.4 Historic Flooding

- 2.4.1 Arun District Council (ADC), West Sussex County Council (WSCC) and the Environment Agency were consulted regarding historic flooding at the site.
- 2.4.2 The Environment Agency did not hold any records of previous flooding events affecting the site.
- 2.4.3 ADC noted the public highway at the junction of the A29 and Sack Lane has suffered historical flooding, and that there may be other areas in Sack Lane that suffered flooding but were not recorded. In addition, ADC SFRA mapping shows the site is not within the identified Historic flood outline, however this is noted to the northeast of the site.
- 2.4.4 WSCC responded that areas adjacent to the site were affected by flooding during the June 2012 event, and records of highway flooding along Sack Lane and the A29. The junction of Sack Lane and the A29 was recorded to be impassable to traffic for some time following the June 2012 event.

2.5 Summary of Flood Risk

- 2.5.1 The potential sources of flooding are:

Source of Flooding	Level of Risk
Rivers and Coastal	Low (Residual Risk: High) The site is in Flood Zone 1, is shown to be primarily at very low risk of flooding from rivers or the sea, and is elevated above existing predicted Environment Agency Flood Levels for fluvial and tidal flooding. SFRA mapping demonstrates that the site is within the expected Flood Zone 3a extents as a result of climate change however, and predicted flood levels show that in an undefended tidal scenario the site is at risk of over a metre depth of flooding in a 0.5% AEP scenario in the 2115 epoch.
Surface Water	Low The long-term flood risk for surface water varies from 'Very Low' to 'Low' at the site location. The majority of the site is at 'very low' risk, with an isolated area at risk and no flooding over 300mm depth expected.
Groundwater	High Consultation with West Sussex County Council identified the site within an area at high risk of groundwater emergence. Site investigation and borehole records show groundwater at less than 1.0m below ground level. No deep excavation that could disturb groundwater flows is proposed. The use of infiltration SuDS will be limited by the presence of groundwater.
Sewers	Very Low There is no known Southern Water or WSCC Highways infrastructure along Sack, following online searches and consultation with the LLFA and LPA. In view of this information the risk of flooding from this source is deemed to be 'Very Low'.
Artificial Sources	None The site is not shown to be at risk of flooding in the event of a breach of a reservoir.

3 SEQUENTIAL AND EXCEPTION TESTS

3.1 Sequential Test

- 3.1.1 The area of proposed development is in Flood Zone 1. In view of this, the application of the sequential test is not required.
- 3.1.2 Investigation of existing site levels from the topographic survey in **Appendix B** and the predicted fluvial and tidal flood levels provided in the Environment Agency Product 4 Response in **Appendix E** shows that the site is wholly elevated above existing and predicted fluvial flood levels. In addition the site is elevated above existing and predicted tidal flood levels in a defended scenario.
- 3.1.3 The proposed site buildings are positioned Sequentially, away from lower lying ground and adjacent to the existing watercourses, with at least 5 metre clearance from existing watercourse banks to proposed buildings.
- 3.1.4 Although the boundary areas to the southeast and northeast of the site are shown to be at the boundary of Flood Zone 2 and 3, and are shown to be below flood levels, these areas are not within the proposed development area and are to be returned to grass and an ecological buffer zone from the existing impermeable hardstanding.
- 3.1.5 In an undefended tidal scenario, flood levels are shown to rise to 3.66 mAOD for the year 2115 epoch, as a result of rising sea levels. As the site is shown to be protected by sea defences for the lifetime of the development, tidal flood risk is residual only and therefore mitigation measures address this risk as detailed within **Section 5.2 - Mitigation**.

3.2 Exception Test

- 3.2.1 The Exception Test is not required, as the site is located in Flood Zone 1 and elevated above fluvial and tidal flood risk levels.

4 PROPOSED DEVELOPMENT

4.1 Description of Development

4.1.1 The proposed development will involve the construction of 8 residential properties as demonstrated within **Appendix A**.

4.1.2 The type of development falls within the 'More Vulnerable' classification (Flood Risk and Coastal Change Table 2) which is appropriate in Flood Zone 1 (Flood Risk and Coastal Change Table 3).

Flood Zones	Flood Risk Vulnerability Classification				
	Essential Infrastructure	Highly Vulnerable	More Vulnerable	Less Vulnerable	Water Compatible
Flood Zone 1	✓	✓	✓	✓	✓
Flood Zone 2	✓	Exception Test Required	✓	✓	✓
Flood Zone 3a†	Exception Test Required †	✗	Exception Test Required	✓	✓
Flood Zone 3b*	Exceptions Test Required *	✗	✗	✗	✓†
✓ = Development is appropriate ✗ = Development should not be permitted					

4.1.3 The post-development impermeable area has been determined to be reduced from 6,687m² (0.67Ha) to 2,364m² (0.24Ha).

4.1.4 The use of Sustainable Drainage System (SuDS) methods and techniques (where site conditions and constraints allow) within the bounds of the site (whilst adhering to the SuDS hierarchy as stated within Building Regulations (Part H) and The CIRIA SuDS Manual C753) will be used to provide a betterment of surface water run-off compared to the existing site.

4.1.5 The specific Surface Water and Foul Water drainage proposals are detailed in **Section 4** of this report.

5 PROPOSED DRAINAGE STRATEGY

5.1 Surface Water

5.1.1 The SUDS manual and Building Regulations set out a hierarchy of drainage methods to ensure that developments maximise the use of sustainable drainage techniques. The hierarchy favours infiltration methods of disposal over other methods such as watercourse and sewers, as detailed below;

- i. Utilise infiltration techniques
- ii. Attenuate rainwater in ponds or open water features for gradual release
- iii. Attenuate rainwater by storing in tanks or sealed water features for gradual release
- iv. Discharge rainwater direct to a watercourse
- v. Discharge rainwater to a surface water sewer/drain
- vi. Discharge rainwater to a combined sewer

SUDS Technique	Suitable	Comments
Living Roof	Yes	No initial constraints but subject to client construction specification.
Basins and Ponds - Constructed wetlands, balancing ponds, detention basins & retention ponds	No	No initial constraints but not suitable due to the limited space available with the proposed layout.
Filter strips and swales	No	Shallow groundwater and risk of emergence limits the use of infiltration techniques
Infiltration Devices - Soakaways, infiltration trenches & basins	No	Shallow groundwater and risk of emergence limits the use of infiltration techniques
Permeable surfaces and filter drains - Gravelled areas, solid paving blocks & porous pavers	Yes	Shallow groundwater and risk of emergence limits the use of infiltration techniques; however this could be considered to capture and attenuate flows.
Tanked systems - Oversized pipes & cellular tanks	Yes	SuDS systems would be depth limited due to the presence of shallow groundwater and flood risk in some areas of the site.

- 5.1.2 As discussed in **Section 1.3** infiltration is not a suitable method for the disposal of surface water run-off. Site-specific geotechnical testing showed that infiltration was poor, and groundwater monitoring results showed that groundwater levels was 0.75m below ground level.
- 5.1.3 In view of 5.1.2, shallow tanked SuDS features are proposed with a controlled discharge to the existing watercourse.
- 5.1.4 It is proposed that tanked permeable paving will be installed across the site for the access road, residential courtyards and shared parking areas. This would provide a plan area of permeable paving totalling 1,287m², with a sub-base thickness of 400mm. Attenuated flows would be conveyed via a perforated pipe at the base of the subbase.
- 5.1.5 It is recommended that prior to detailed drainage design to discharge planning conditions, shallow infiltration testing to BRE365 compliance is undertaken above the maximum recorded groundwater level of 0.75mbgl to assess the permeable pavement soakage potential, and that should it be appropriate a permeable geotextile lining is used at the base of the subbase to utilise any infiltration potential, subject to approval from Arun District Council.
- 5.1.6 Discharge to the watercourse would be controlled by an induce vortex flow control, restricting the rate to 2.0 l/s.
- 5.1.7 The proposed strategy accounts for a critical design event of 1 in 100 years plus an allowance for 40% climate change, without exceedance flooding, as shown in the hydraulic modelling calculations in **Appendix F**.
- 5.1.8 The strategy above will ensure that there is no increase in the rate of run-off leaving the site, therefore no increase in the risk of flooding from this source.

5.2 Treatment

- 5.2.1 The use of permeable paving will ensure that run-off from the site receives a level of treatment required by the SuDS manual, with hydrocarbons being filtered by the aggregate and geotextile layers.
- 5.2.2 In accordance with the CIRIA SuDS Manual C753 regarding methods for managing pollution risks, the risk posed by surface water runoff to the receiving environment depends on the pollution hazard at the site (the source), SuDS treatment techniques (the pathway), and the sensitivity of the environment (the receptor).
- 5.2.3 The simple index approach considers whether SuDS techniques are appropriate for the site. The states that for SuDS components to deliver adequate treatment, the total pollution mitigation index for each contaminant type should equal or exceed the pollution hazard index.
- 5.2.4 The SuDS Manual outlines three categories of pollution hazard identification, which vary depending on proposed land use, which are as follows:
- Total Suspended Solids (TSS).
 - Metals (M).
 - Hydrocarbons (H).

5.2.5 In accordance with C753 Table 26.2, the proposed land uses at the site are categorised as follows:

- Residential Roofs – very low/TSS=0.2/M=0.2/H=0.05
- Individual property driveways and low traffic roads – low/TSS=0.5/ M=0.4/H=0.4

5.2.6 In accordance with C753 Table 26.3, the values of SuDS Mitigation indices are provided for permeable paving:

- Permeable Pavement – TSS=0.7/M=0.6/H=0.7

5.2.7 As the pollution hazard index does not exceed any pollution mitigation index for any contaminant type, for any proposed land use, the proposed SuDS methods will provide sufficient treatment for the residential areas.

5.3 Foul Water Drainage

5.3.1 As there is no existing foul mains drainage on Sack Lane, a sewage treatment plant will be required with treated effluent discharged to the watercourse.

5.3.2 The proposed sewage treatment plant will need to cover the General Binding Rules, and have an Environment Agency Approved Permit to discharge to the watercourse, if discharge is more than 5 cubic metres of effluent per day. The calculation for daily discharge is dependent on property sizing and number of bedrooms. Based on the Environment Agency daily discharge calculations for domestic properties, 8 No. 3-bedroom properties would result in 4.8 cubic metres foul discharge per day ($8 \times 3 \times 0.15\text{m}^3/\text{day}$).

5.3.3 It should also be noted that the foul discharge should be to a watercourse with a constant flow. Should this not be viable, then a foul drainage field would also be necessary prior to discharge to the ditch.

5.4 Climate Change

5.4.1 In July 2020 the Environment Agency updated the latest climate change allowances (available online at <https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances>), which supports the NPPF in making an allowance for climate change within flood risk assessment. The allowances provide predictions of anticipated change for peak river flow by river basin district, peak rainfall intensity, sea level rise and extreme wave height.

5.4.2 Peak river flow allowances show the anticipated changes to peak flow by river basin. The table below shows the peak river flow allowances for the South East basin.

Table 1: peak river flow allowances by river basin district			
South East basin	Total potential change anticipated for the '2020s' (2015 to 2039)	Total potential change anticipated for the '2050s' (2040 to 2069)	Total potential change anticipated for the '2080s' (2070 to 2115)
H++	30%	60%	120%

Upper End	25%	50%	105%
Higher Central	15%	30%	45%
Central	10%	20%	35%

5.4.3 As the site is in Flood Zone 1 but classified as 'more vulnerable' as noted in **Section 4**, the higher central and upper end allowances must be assessed with respect to increased fluvial flood risk and river flood levels for the proposed development. An increase of 105% to peak river flow has been assessed for this development.

5.4.4 The table below shows the anticipated changes in extreme rainfall intensity for small and urban catchments. For flood risk assessments, both the central and upper end allowances should be assessed to understand the range of impact.

Table 2: peak rainfall intensity allowance in small catchments			
Applies across all of England	Total potential change anticipated for the '2020s' (2015 to 2039)	Total potential change anticipated for the '2050s' (2040 to 2069)	Total potential change anticipated for the '2080s' (2070 to 2115)
Upper End	10%	20%	40%
Central	5%	10%	20%

5.4.5 NPPF sets out percentage increases to be applied to the peak rainfall intensity values used in the design of a surface water drainage system to allow for the effects of climate change. An increase of 20% should be applied for this development and a review should be undertaken to determine the impact of an increase of 40%. A 40% level of increase in rainfall intensity has been accounted for within the overall drainage strategy for the site.

5.4.6 Sea level allowances show the predicted rise in sea level rise for each river basin district and epoch. The table below shows the sea level rises for the South East.

Table 3: sea level allowances by river basin district for each epoch	
South East	Cumulative rise 2000 to 2125 (metres)
Upper End	1.60
Higher Central	1.20

5.4.7 As detailed in **Section 2.2**, a sea level rise of over 1.60 metres has been assessed with respect to the residual risk of undefended tidal levels.

5.5 Urban Creep

5.5.1 The proposed drainage strategy has been designed with an assumption of a 10% increase in impermeable area in the lifetime of the development due to urban creep, and the calculations show sufficient capacity during the design rainfall event with the urban creep allowance.

6 RESIDUAL RISK AND MITIGATION

6.1 Residual Risk

6.1.1 The following residual risks have been identified in relation to the proposed development:

- i. Flooding of buildings due to the combination of sea level rise and failure/breach of sea defences
- ii. Blockage of watercourses as a result of debris or otherwise, causing flooding to the site.
- iii. Extreme rainfall events that exceed the design criteria used for the drainage system causing surface water flooding.
- iv. Blockage/failure of the proposed drainage system causing flooding to the site.
- v. Groundwater flooding to the site caused by groundwater levels exceeding the ground surface level.

6.2 Mitigation

6.2.1 Consideration has been taken to the residual risks stated in Section 5.1, and the following mitigation measures are proposed:

- i. Finished floor levels are raised above external ground levels, and no bedrooms are proposed on the ground floor. In addition, it is recommended that flood resilient construction methods are used along with flood proofing measures;
- ii. As detailed in **Section 8**, maintenance measures will include clearance of Riparian watercourse banks that lie within the site boundaries.
- iii. The drainage strategy has been developed to capture runoff up to a 1 in 100-year critical rainfall event, with 40% allowance for climate change. Preliminary design levels have been detailed in Drawing **D1922-200**, to flow towards the low point in the centre for surface water discharge, and towards the watercourses away from the proposed buildings at the rear of all properties. Proposed finished floor levels have also been set above surrounding ground levels.
- iv. The proposed drainage system will attenuate and store runoff up to the design event. Blockage of the drainage system has the potential to cause flooding on the site. Surcharged flows will likely travel overland to the existing drainage system and watercourse, however maintenance measures proposed in Chapter 8 will mitigate the risk of the system becoming blocked.

- v. Due to the underlying ground conditions of the site and the presence of groundwater in the upper layers, there is a risk of groundwater exceeding the surface level and emerging on the site. There are no records of previous groundwater flooding, however. If groundwater flooding were to occur, it would flow away from the proposed buildings into the existing drainage gullies and the watercourse ditches, or via the proposed drainage system.

7 FLOOD RISK MANGEMENT

7.1 Safe Access and Egress

- 7.1.1 A safe access and egress route is provided to higher ground, to the west along Sack Lane, so that any residual risk to future residents can be safely managed.

7.2 Flood Warning

- 7.2.1 The site is within a Flood Warning Area as shown on the Arun District Council SFRA Mapping.
- 7.2.2 It is recommended that a Flood Evacuation Plan (FEP) is produced to address the residual risk of tidal flooding for the lifetime of the development. This should include provision of a Flood Warning System.

8 MAINTENANCE

8.1 Proposed Maintenance Regime

8.1.1 Maintenance is required to ensure the long-term operational performance of the proposed surface water drainage system.

8.1.2 The drainage system has been designed to minimise maintenance requirements; however a number of key tasks will need to be undertaken so that the system remains in optimal condition. These operations are summarised in the table below, along with the required frequency of works.

Drainage System feature	Proposed maintenance / remedial works	Required frequency of works
Permeable Paving	Surface sweeping to reduce silt and debris accumulation.	Every 8 to 12 weeks
	Removal / management of weed growth	At least once a year
	Silt removal from permeable surfaces, possibly involving raking out of joints, redressing, removal and remedial works.	As required / to be specified by manufacturer
Diffuser units & catch pits, gully sumps and drains	Inspection and additional cleansing as required.	Annual
	Desilting	Year 1, Year 3, then every 5 years
Pipework	Jetting to clear blockages	As required
Hydrobrake	As specified by manufacturer	As specified by manufacturer
Existing Watercourse & Headwall Outfall	Inspection, vegetation clearance and additional clearing/cleansing of potential outfall blockages	At least once a year
	Desilting	Year 1, Year 3, then every 5 years

8.1.3 The responsibility of maintenance regime will be determined by the Developer, by agreed appointment.

Permeable Paving / Diffuser Units

8.1.4 The areas of permeable paving are designed to allow infiltration of surface water run-off through the joints in the block paving surface course and into the subbase below. The water is then collected and discharged into the positive drainage system.

8.1.5 As part of the permeable paving system, diffuser units are used to discharge surface water run-off from roof areas into the sub-base, as well as forming links between areas of permeable paving. These diffuser units are small heavy-duty cellular units which allow more efficient discharge of surface water into the sub-base base of the permeable paved areas.

8.1.6 The areas of permeable paving will require additional maintenance measures to ensure they operate as designed. Failure in carrying out this maintenance, could increase the risk of flooding. The additional measures are as follow:

- Periodic surface sweeping to reduce silt and debris accumulation. The permeable surfaces should be swept at least every 8 to 12 weeks with additional sweeps in the autumn to clear fallen leaves
- Removal / management of weed growth, as required. Typically, once or twice a year for regularly used areas
- Periodic silt removal from permeable surfaces as described by the manufacturer. If any areas are showing signs of ponding, they shall be dealt with by raking out the joints and redressing. The entire surface shall be monitored and when there are signs of excessive siltation resulting in poor drainage over the whole area, the blocks shall be taken up and a replacement of bedding layer and geotextile shall be undertaken
- Redressing of joints on the block paving as required
- Catchpits upstream of diffuser units, should be emptied and inspected on the same regime as all catchpits specified previously set out in this document

Flow Control Chamber

- 8.1.7 The flow control system is self-activating, relying on upstream hydraulic head to generate an air-filled vortex within the centre of the casing. Once the vortex is initiated water drains down through a small opening in the back of the device at the designed restricted flow rate.
- 8.1.8 The flow control device has two measures encase of emergency (i.e. blockage). The first is a door situated in the front of the unit itself, this can be operated from the surface by a release cable situated just under the manhole cover which closes under its own weight and does not require any mechanism to operate. The second is a high-level overflow pipe situated with the flow control manhole. Both measures allow the system to drain down freely, until the blockage can be cleared.
- 8.1.9 The flow control chamber will require additional maintenance measures to ensure it operates as designed. The additional measures are as follow:
- The sump within the flow control chamber should be monitored for build-up of silts and should be emptied, as a minimum, on the same regime as specified for catchpits previously within this document
 - The drain down door located on the centre of the unit will require inspection and opening annually, to ensure it is operating as intended

Outfall & Existing Watercourse

- 8.1.10 A proposed outfall will be required for the discharge from the site out to the boundary ditch. It is recommended that maintenance of the outfall feature and the existing ditch is carried out to ensure conveyance off the site and prevent the risk of blockages and flooding, with measures as follows:

- Inspection, vegetation clearance of riparian banks and additional clearing/cleansing of potential outfall blockages will be required on an annual basis.
- Desilting is recommended at least as follows: On completion of drainage works, Year 1, Year 3, then every 5 years.

Remedial/Repair Actions

- 8.1.11 Significant storm events may cause considerable damage to SuDS and their associated components. As such, it may be necessary to inspect and carry out essential recovery works to return the feature to full working order.
- 8.1.12 Resetting of uneven blocks by lifting block area, removing bedding material and relaying to match original design are all actions which may need to be undertaken.

Accidental Spillages

- 8.1.13 It is not envisaged that any materials are to be stored onsite once the development has been completed, which could cause major spills and potential pollution issues within the drainage system. If this situation alters in the future consultation with a specialist will be required in order to confirm if any upgrades to the existing system are necessary.
- 8.1.14 Minor spillages of fuels and oils from motor vehicles will be dealt with by the permeable paving and deep trapped gullies, by bio-degrading and collecting the hydrocarbons respectively.

Future Alterations to the Development

- 8.1.15 Any future alterations to the permeable paving should be confirmed by a specialist. Where possible any future services are to avoid being located through areas of permeable paving. If new services are required to run through areas of permeable paving, services should be installed below the depth of permeable paving with the permeable system reinstalled above.

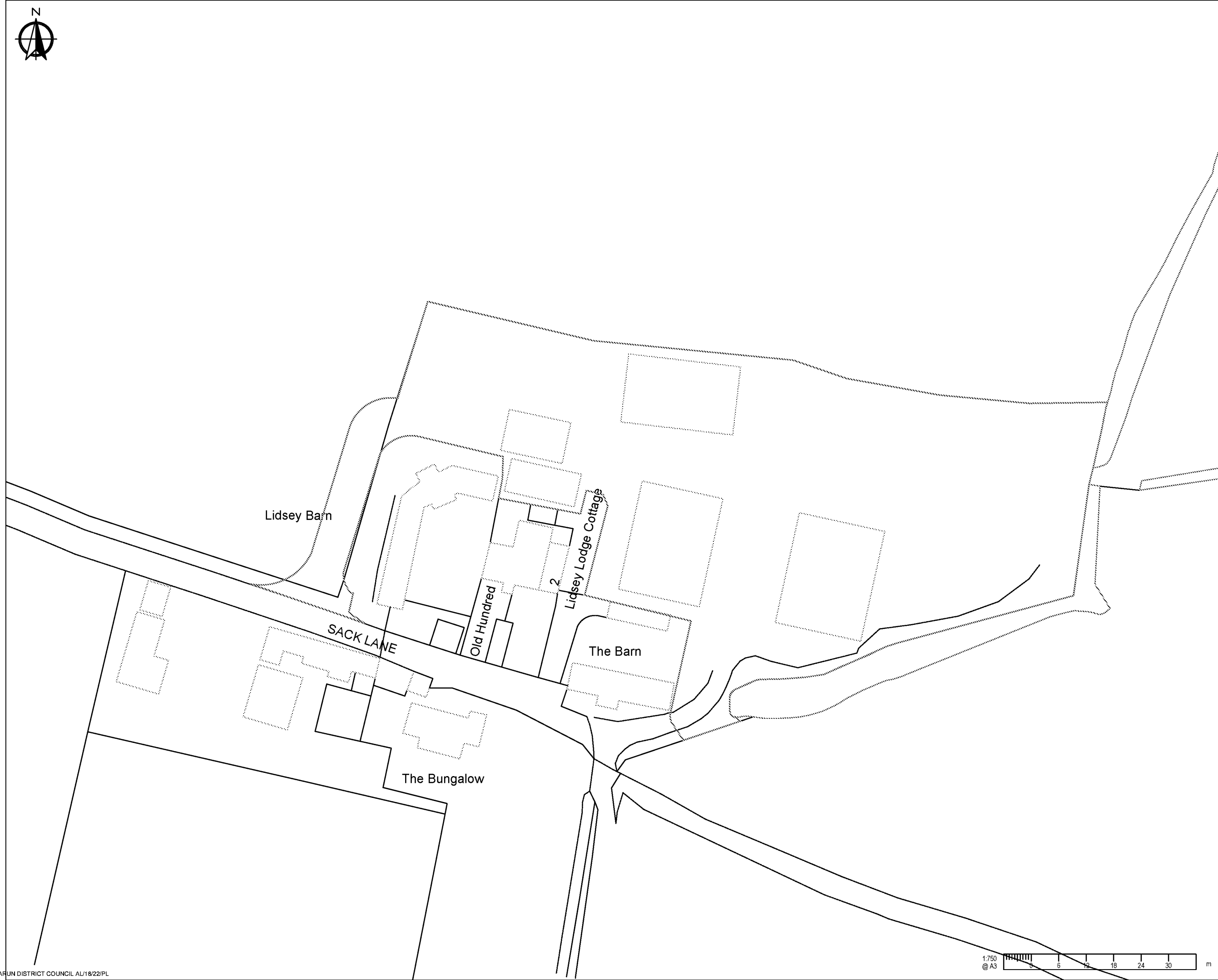
9 OFFSITE IMPACTS

- 9.1.1 The proposed development will have a positive impact on flooding issues off-site by reducing run-off rates and discharge to the surface water drain via shallow attenuation within sustainable drainage systems.
- 9.1.2 Post development foul water flows will contribute an increase compared to the previous use – it is expected that the foul sewer flow will be 0.40l/s, however this will be offset by the reduction in surface water runoff.
- 9.1.3 The effects of climate change have been considered in the design of the proposed surface water drainage system, to ensure there is no off-site impact.

10 SUMMARY

- 10.1.1 This site-specific flood risk assessment is based on Flood Maps, the Local Authority's Strategic Flood Risk Assessment and Public Sewer Records.
- 10.1.2 The site an existing agricultural yard with several large storage barns.
- 10.1.3 The development lies within Flood Zone 1, however is subject to a residual risk of tidal flooding as a result of climate change and sea level rise within the lifetime of the development.
- 10.1.4 The existing site is predominantly hardstanding, with no confirmed existing drainage infrastructure. Post-development surface water run-off will be managed through sustainable drainage measures, with the installation of permeable paving meaning overland flows can be attenuated on site and released to the existing watercourse at a rate with a significant betterment, without causing surface water flooding on site.
- 10.1.5 The wastewater from the proposed development will discharge via a sewage treatment plant with treated effluent discharged to the existing watercourse.
- 10.1.6 Flood mitigation measures address the residual risk of tidal flooding as a result of climate change and sea level rise.
- 10.1.7 The completion of the development will not increase flood risk on or off the site.
- 10.1.8 Information has been provided to state why this development passes the Sequential Test and the Exception Test.
- 10.1.9 In conclusion, this development is suitable with regards to flood risk and surface water drainage.

DRAWINGS



NOTES

1. This drawing is to be read in conjunction with all other Bright Plan Civils drawings, and with all relevant Architects and Engineer's drawings and specification. Any discrepancies found are to be reported immediately to the Engineer.

2. Bright Plan Civils accepts no responsibility for inaccuracies in data provided by third parties such as topographic surveys or Ordnance Survey mapping.

3. Do not scale, work to figured dimensions only. All dimensions are in millimeters unless noted otherwise and all levels are in metres from the topographic survey datum.

4. Any information given regarding existing underground services is given in good faith after consultation with the relevant authority, however accuracy is not certain

-SITE LOCATION LEGEND-

Site Boundary - 8,200 m² (0.82 Ha.)

Site Grid Reference: SU 94559 02613

PLANNING

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A

Revised Layout

04-06-2021

Rev

Amendments

Date

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Tel: 01243 210418

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Drawing Status

PLANNING

Client

Melanie Jenkins

Project

Site Location Plan

Drawing Title

Lidsey Lodge Farm

Sack Lane, Lidsey PO22 9PE

Scale

1:750

Date

Jun 2021

Drawn By

DJL

Checked By

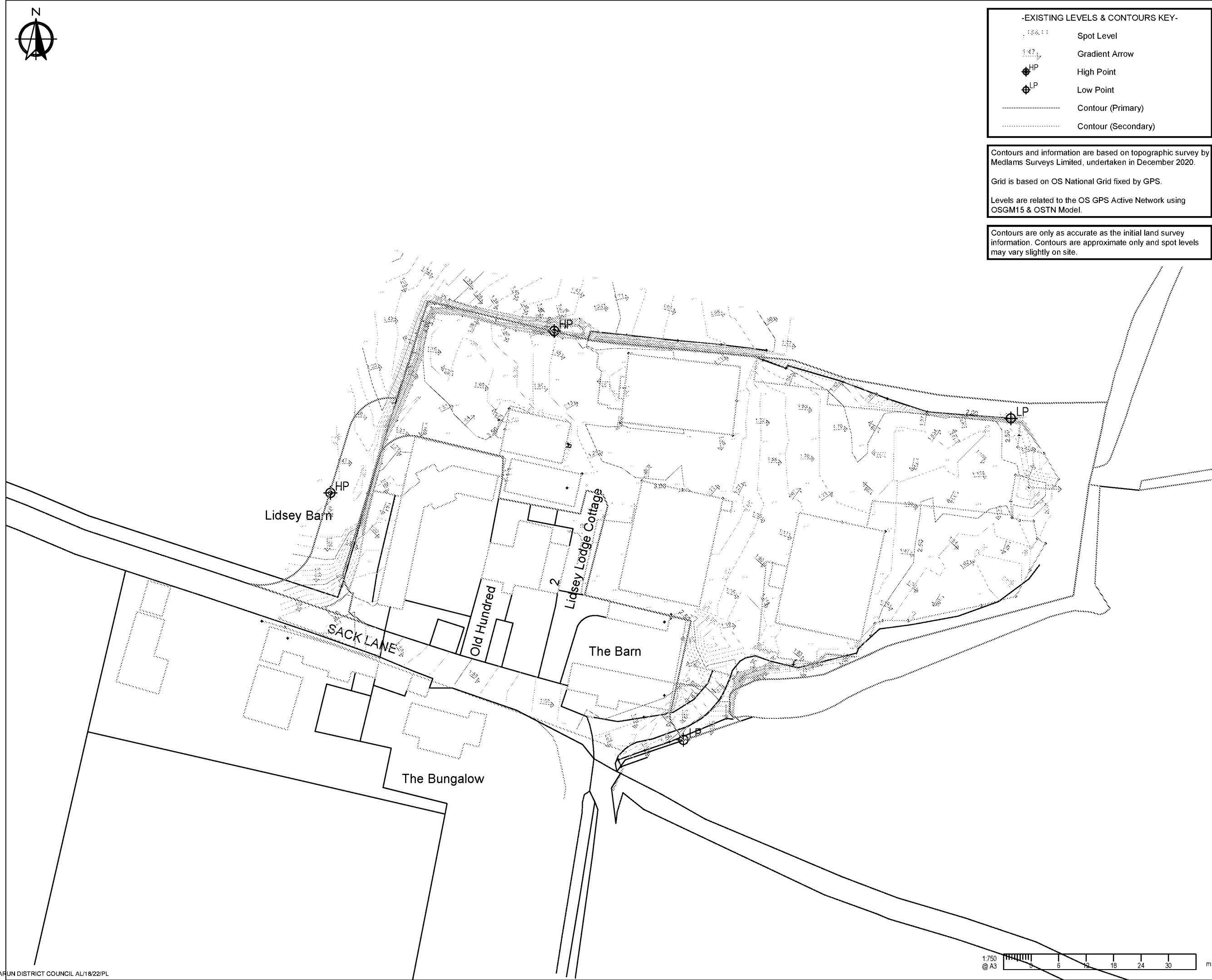
LDF

Drawing No.

D1922-100

Rev.

A



-EXISTING LEVELS & CONTOURS KEY-

	Spot Level
	Gradient Arrow
	High Point
	Low Point
	Contour (Primary)
	Contour (Secondary)

Contours and information are based on topographic survey by Medlams Surveys Limited, undertaken in December 2020.

Grid is based on OS National Grid fixed by GPS.

Levels are related to the OS GPS Active Network using OSGM15 & OSTN Model.

Contours are only as accurate as the initial land survey information. Contours are approximate only and spot levels may vary slightly on site.

NOTES

A3

1.

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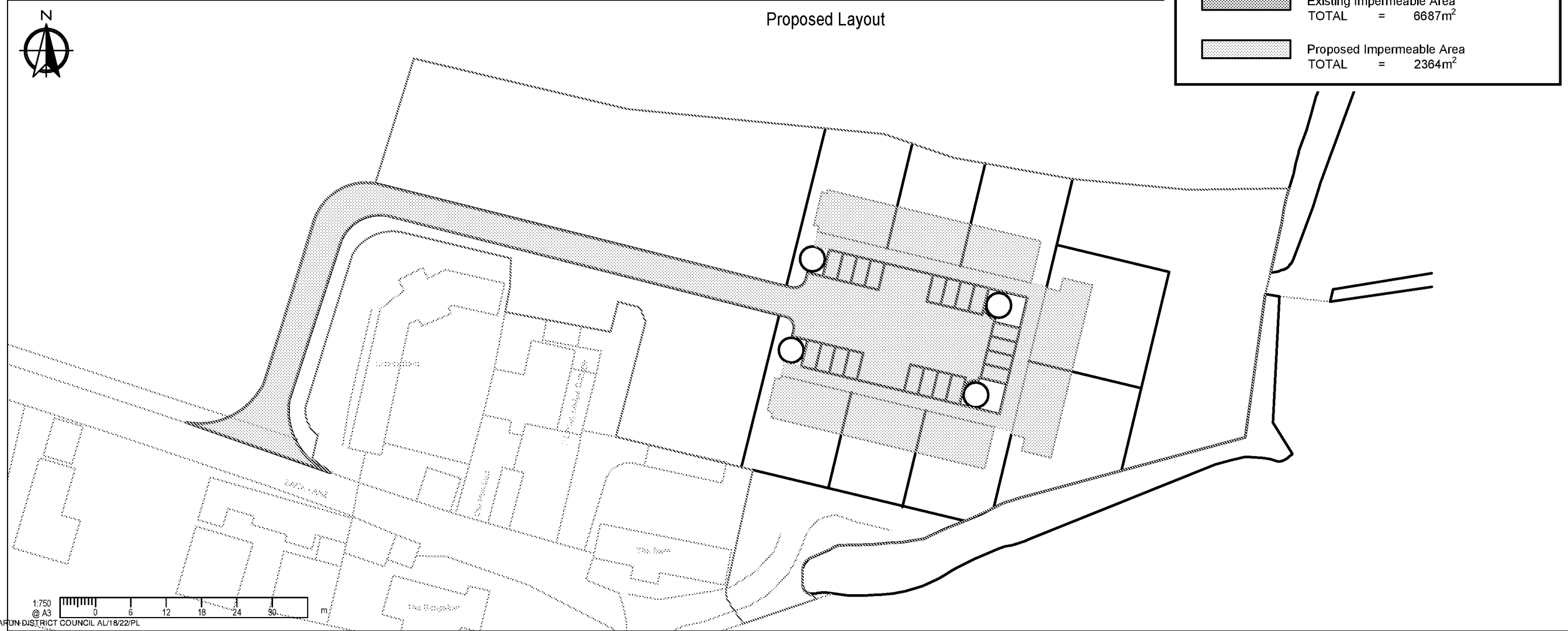
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Drawing Status	PLANNING							
Client	Melanie Jenkins							
Project	Overland Flow Routes							
Drawing Title	Lidsey Lodge Farm Sack Lane, Lidsey PO22 9PE							
Scale	1:750	Date	Jun 2021	Drawn By	DJL	Checked By	LDF	
Drawing No.	D1922-101						Rev.	A



-CATCHMENT KEY-	
	Site Boundary Area
	TOTAL = 8382m ²
	Existing Impermeable Area
	TOTAL = 6687m ²
	Proposed Impermeable Area
	TOTAL = 2364m ²

NOTES

A3

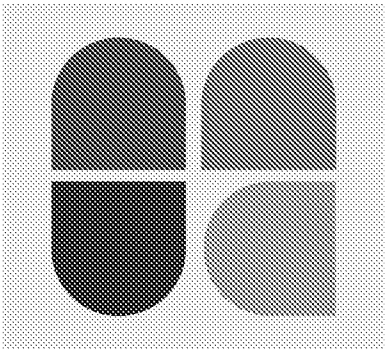
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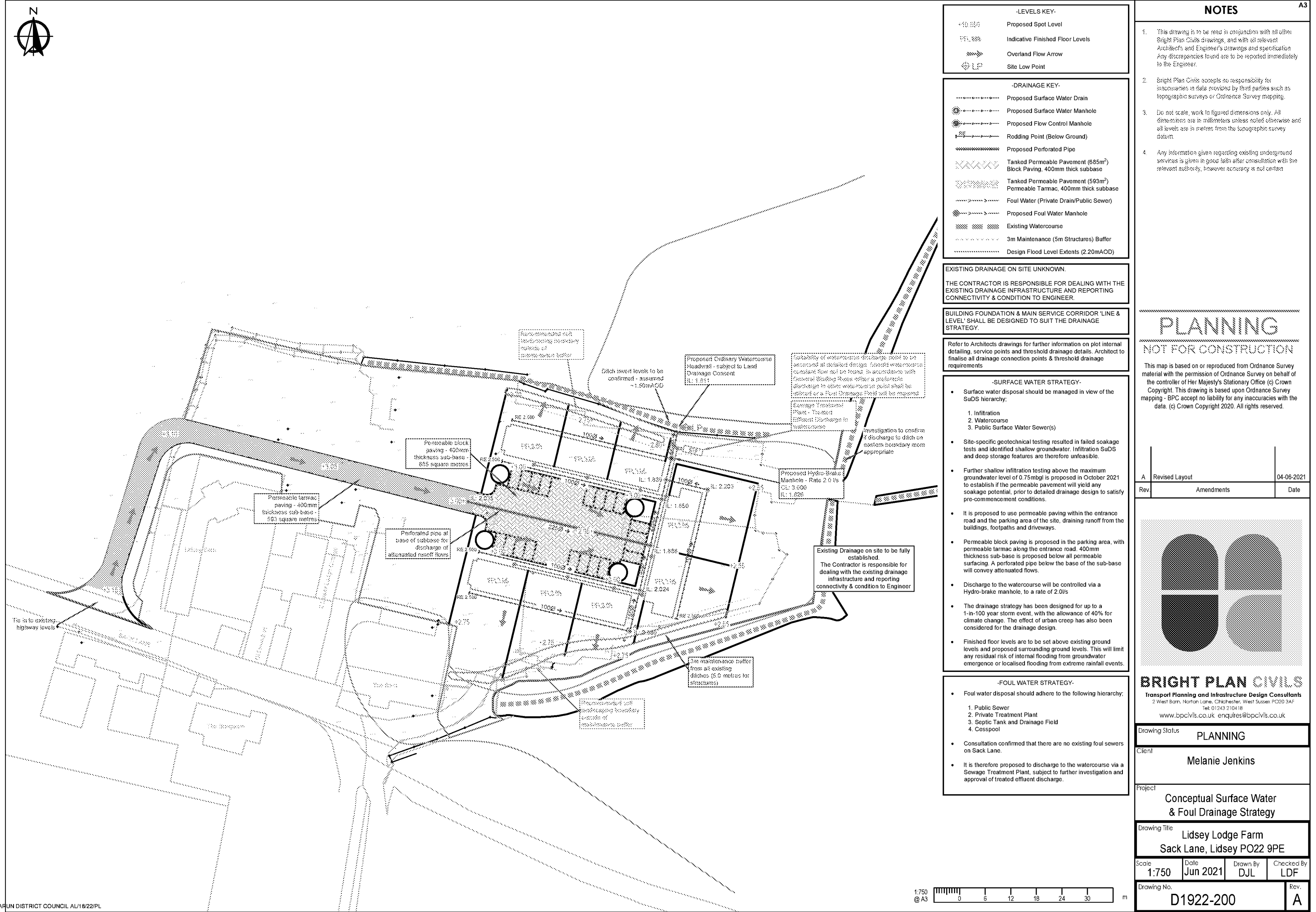
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Rev	Amendments	Date



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Drawing Status	PLANNING		
Client	Melanie Jenkins		
Project	Impermeable Areas		
Drawing Title	Lidsey Lodge Farm Sack Lane, Lidsey PO22 9PE		
Scale	1:750	Date	Jun 2021
Drawn By	DJL	Checked By	LDF
Drawing No.	D1922-102		Rev. A



-LEVELS KEY-	
	Proposed Spot Level
	Indicative Finished Floor Levels
	Overland Flow Arrow
	Site Low Point

-DRAINAGE KEY-	
	Proposed Surface Water Drain
	Proposed Surface Water Manhole
	Proposed Flow Control Manhole
	Rodding Point (Below Ground)
	Proposed Perforated Pipe
	Tanked Permeable Pavement (685m²) Block Paving, 400mm thick subbase
	Tanked Permeable Pavement (593m²) Permeable Tarmac, 400mm thick subbase
	Foul Water (Private Drain/Public Sewer)
	Proposed Foul Water Manhole
	Existing Watercourse
	3m Maintenance (5m Structures) Buffer
	Design Flood Level Extents (2.20m AOD)

EXISTING DRAINAGE ON SITE UNKNOWN.
THE CONTRACTOR IS RESPONSIBLE FOR DEALING WITH THE EXISTING DRAINAGE INFRASTRUCTURE AND REPORTING CONNECTIVITY & CONDITION TO ENGINEER.

BUILDING FOUNDATION & MAIN SERVICE CORRIDOR 'LINE & LEVEL' SHALL BE DESIGNED TO SUIT THE DRAINAGE STRATEGY.

Refer to Architects drawings for further information on plot internal detailing, service points and threshold drainage details. Architect to finalise all drainage connection points & threshold drainage requirements

- SURFACE WATER STRATEGY-**
- Surface water disposal should be managed in view of the SuDS hierarchy;
 1. Infiltration
 2. Watercourse
 3. Public Surface Water Sewer(s)
 - Site-specific geotechnical testing resulted in failed soakage tests and identified shallow groundwater. Infiltration SuDS and deep storage features are therefore unfeasible.
 - Further shallow infiltration testing above the maximum groundwater level of 0.75m bgl is proposed in October 2021 to establish if the permeable pavement will yield any soakage potential, prior to detailed drainage design to satisfy pre-commencement conditions.
 - It is proposed to use permeable paving within the entrance road and the parking area of the site, draining runoff from the buildings, footpaths and driveways.
 - Permeable block paving is proposed in the parking area, with permeable tarmac along the entrance road. 400mm thickness sub-base is proposed below all permeable surfacing. A perforated pipe below the base of the sub-base will convey attenuated flows.
 - Discharge to the watercourse will be controlled via a Hydro-brake manhole, to a rate of 2.0l/s
 - The drainage strategy has been designed for up to a 1-in-100 year storm event, with the allowance of 40% for climate change. The effect of urban creep has also been considered for the drainage design.
 - Finished floor levels are to be set above existing ground levels and proposed surrounding ground levels. This will limit any residual risk of internal flooding from groundwater emergence or localised flooding from extreme rainfall events.

- FOUL WATER STRATEGY-**
- Foul water disposal should adhere to the following hierarchy;
 1. Public Sewer
 2. Private Treatment Plant
 3. Septic Tank and Drainage Field
 4. Cesspool
 - Consultation confirmed that there are no existing foul sewers on Sack Lane.
 - It is therefore proposed to discharge to the watercourse via a Sewage Treatment Plant, subject to further investigation and approval of treated effluent discharge.

NOTES

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Rev	Amendments	Date

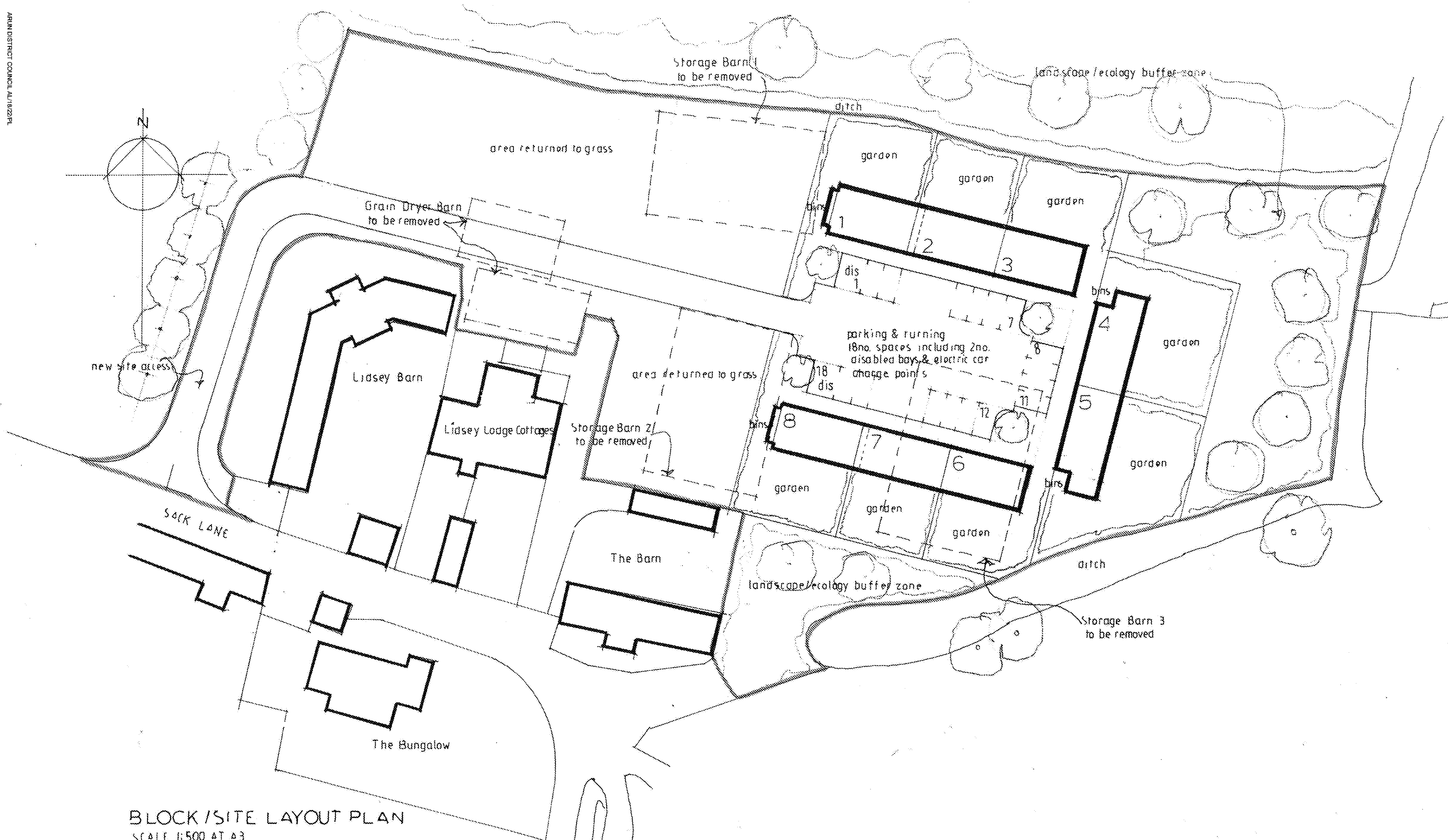
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Drawing Status	PLANNING							
Client	Melanie Jenkins							
Project	Conceptual Surface Water & Foul Drainage Strategy							
Drawing Title	Lidsey Lodge Farm Sack Lane, Lidsey PO22 9PE							
Scale	1:750	Date	Jun 2021	Drawn By	DJL	Checked By	LDF	
Drawing No.	D1922-200						Rev.	A

1:750 @ A3

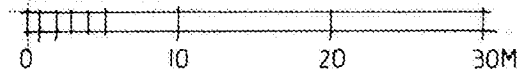
APPENDICIES

Appendix A Preliminary Site Layout



BLOCK / SITE LAYOUT PLAN

SCALE 1:500 AT A3



RJCA Chartered Architects

The White House, 2 Lavant Road
Chichester, West Sussex PO19 5RQ

Tel: 01243 779600

Mobile: 07973435493

Email: rjcatkinson@btinternet.com

Project Name: Lidsey Lodge Farm

Drawing: Site layout and block plan

Drawing Number: 2020/10/11

Rev.

G

Appendix B Topographical Survey



ABBREVIATIONS (where applicable)			
AV	Air Valve	MH	Manhole Cover
BK	Brick	MK	Marker
BL	Bollard	MS	Milestone
BS	Bus Stop	MT	Meter
BT	British Telecom	MY	Mercury
CB	Control Box	OH	Overhead
C/B	Close Boarded	PAV	Paving
CL	Cover Level	PB	Post Box
CLK	Chainlink	PE	Pipe
CO	Column	PM	Parking Meter
Conc	Concrete	P/R	Post and Rail
CP	Catch Pit	PT	Post
CPS	Concrete Paving Slabs	P/W	Post and Wire
DC	Drainage Channel	RE	Rodding Eye
DP	Drain Pipe	RET	Retaining
EC	Electricity Cover	RS	Road Sign
ER	Earthing Rod	RSJ	Rollad Steel Joist
FB	Flower Bed	SC	Stop Cock
FE	Fence	SK	Skelway
FH	Fire Hydrant	SP	Signpost
FL	Floor Level	ST	Silt Trap
FP	Flag Pole	SV	Stop Valve
GP	Gate Post	SVC	Security Video Camera
GV	Gas Valve	TCB	Telephone Call Box
GY,G	Gully	TK	Tank
HT	Height	TL	Traffic Light
IC	Inspection Cover	TP	Telegraph Pole
IL	Invert Level	UG	Underground
IN	Interceptor	UTF	Unable To Trace Further
I/R	Iron Railings	UTL	Unable To Lift
KO	Kerb Outlet	VP	Vent Pipe
LB	Litter Bin	WL	Water Level
LP	Lamp Post	WM	Water Meter
		WO	Wash Out

NOTES

Survey accurate at time of site attendance. Do not scale from printed drawings except for planning purposes.

Grid is based on ordnance survey national grid fixed by GPS satellite active network. Levels are related to the ordnance survey GPS active network and transformed using the OSBM15 & OSTN15 model.

Drainage pipe sizes (where shown) have been gauged from the surface for safety reasons and should be regarded as approximate only.

Tree species (where shown) should be treated with caution and expert identification is advised.

Although this is a digital survey the accuracy and amount of detail shown is only commensurate with the graphical scale of mapping as specified. Care should be exercised when working to larger scales.

Visible features in the vicinity of the boundaries as shown above, may not represent the extent of legally conveyed ownership.

Whilst every effort has been made to achieve accuracy on this plan, CRUCIAL clearance dimensions, levels and invert levels should be checked prior to design and construction.

Areas of dense undergrowth cannot be surveyed in detail, these areas will be shown in outline only and marked as 'dense undergrowth' on the plan.

Kerb levels have been taken on the top of the channel.

ORDNANCE OVERLAY
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Ordnance Survey Overlay
National Grid 1:2500 (Accuracy data) Surveying tolerances:
Distances up to 200 metres ± 1 in 100m
Distances 200 to 1,000 metres ± 2 m
Distances over 1,000 metres ± 1 in 500m

Appendix C Geotechnical Information

14 Sulphates

2 No. samples of the gravelly sandy clay were tested for sulphate content and pH. In accordance with the BRE¹⁵ methodology and the number of samples tested, the site has been classified on the highest measured sulphate content.

Based on the results detailed in Section E and the above, the soils are classified by the BRE as sulphate design class DS-I, and, assuming a mobile groundwater table, the ACEC class is AC-I.

15 Groundwater

The groundwater monitoring results/observations are given in Section D. On the basis of these results, groundwater at about 1-1.5m below ground level should be anticipated.

Long term groundwater monitoring is currently being undertaken in order to assess the groundwater regime during the winter months, when groundwater levels are expected to be at their highest. 2No. visits have been completed to date.

16 Soakage Potential

16.1 Test Results

2 No. soakage tests were undertaken on site in WSI and 2 in general accordance with BRE365¹⁶ but modified for the smaller diameter test. These windowless holes were drilled at locations specified by the client, as shown in Figure 3 Appendix B. Given the time restrictions, it was only possible to fill and test each windowless hole once. The results are attached in Appendix I and are summarised below:

Table 17: Summary of soakage tests

Borehole	Test Depth (mBGL)	Duration of test (mins)	Water level at beginning of test (mBGL)	Water Level at the end of test (mBGL)	Comments
WSI	1-2	270	0.93	0.7	Water level rose during test, soakage rate calculation not applicable

¹⁵ Building Research Establishment Special Digest I: 2005. Concrete in aggressive ground. Part 1: Assessing the aggressive chemical environment.

¹⁶ Building Research Establishment DG365: 2016. Digest Soakaway Design

WS2	I-2	320	I	I.05	Results not compliant with BRE365 requirements since water level did not fall to 25% max water depth
-----	-----	-----	---	------	--

The water level in WS2 dropped by 5cm in just over 5 hours, and the water level in WSI rose by 23cm in 4.5 hours. It should be noted that there were occasional episodes of light rainfall during the monitoring period.

16.2 Recommendations

Due to the extremely low soakage rates, it was not possible to calculate an exact permeability value for the borehole soakage locations. However, based on field observations and high water table it can be concluded that conventional soakaways are not likely to be successful on site, and allowance should be made for surface water to be piped off site at this stage.

CIRIA C574 “Engineering in Chalk” states that soakaways should be sited a minimum of 10m away from foundations on low density chalk or where the density of the chalk is unknown, and a minimum of 5m on medium or higher density chalk. This reflects the fact the concentrated flows of water through low density chalk will result in dissolution of the chalk or destabilise the backfill in existing dissolution features. Settlement should therefore always be anticipated around soakaways in low density chalk.

In areas where solution features are “known to be prevalent”, CIRIA C574 states that “soakaways should be avoided if possible but, if unavoidable, should be sited at least 20m away from any foundations”.

Further testing may be required for the final drainage design. In particular, full scale soakage tests as per DG365 are recommended within the proposed discharge zone and at the proposed soakaway and/or SUDs locations. It is noted that the soakage testing and groundwater monitoring were carried out during the winter months, and so it is likely that both have been carried out on a worst-case scenario

Direct discharge of clean, uncontaminated roof water to groundwater may be permitted, provided that the discharge is via separate, sealed downpipes.

Five post site investigation groundwater monitoring rounds have subsequently taken place in the two wells in WS3 and 4.

At the time of the intrusive investigation, the weather was overcast with occasional light rain.

Throughout the monitoring period, the rainfall across the UK was generally higher than average (for example 113% of average in January, and 116% in February).

A site plan for the location of each excavation is presented in Figure 2 of Appendix B.

4 Ground Conditions

The logs created for each borehole are presented in Appendix C and summarised in the table below.

Table 1: Summary of soils encountered

Depth From (m)	Depth To (m)	Soil Type	Description
GL / 0.02	0.13 / 0.2	CONCRETE	Concrete (all locations except WS2)
GL / 0.2	0.29 / 0.9	MADE GROUND	MADE GROUND composed of varying mixtures of clay, silt, sand, and gravel. Gravel consists of flint, chalk, brick, concrete in varying proportions and sizes (from fine to coarse).
0.29 / 0.9	0.85 / *4.0	GRAVELLY SANDY CLAY	Soft to firm brown/reddish brown/grey gravelly sandy CLAY. Gravel is fine to coarse sub-angular to angular flint and fine to medium rounded to sub-angular chalk. RIVER TERRACE DEPOSITS
0.85 / 4.0	*2 / *4.45	CHALK	Pale greyish/brownish white extremely weathered CHALK recovered as gravelly clayey silt/clay. Gravel is fine to medium sub-angular to rounded chalk and fine to coarse rounded to angular flint. Grade Dm. (all locations except WS4)

* Denotes full depth of investigation

The ground across the site was found to comprise made ground over sandy/gravelly clay over weathered chalk. The chalk was encountered in all boreholes with the exception of WS4 where the superficial deposits extended to the base of the hole (4m). The depth to the top of the chalk varied between 0.85 to 4m.

4.1.1 Groundwater

Groundwater strikes were recorded in the following trial holes:-

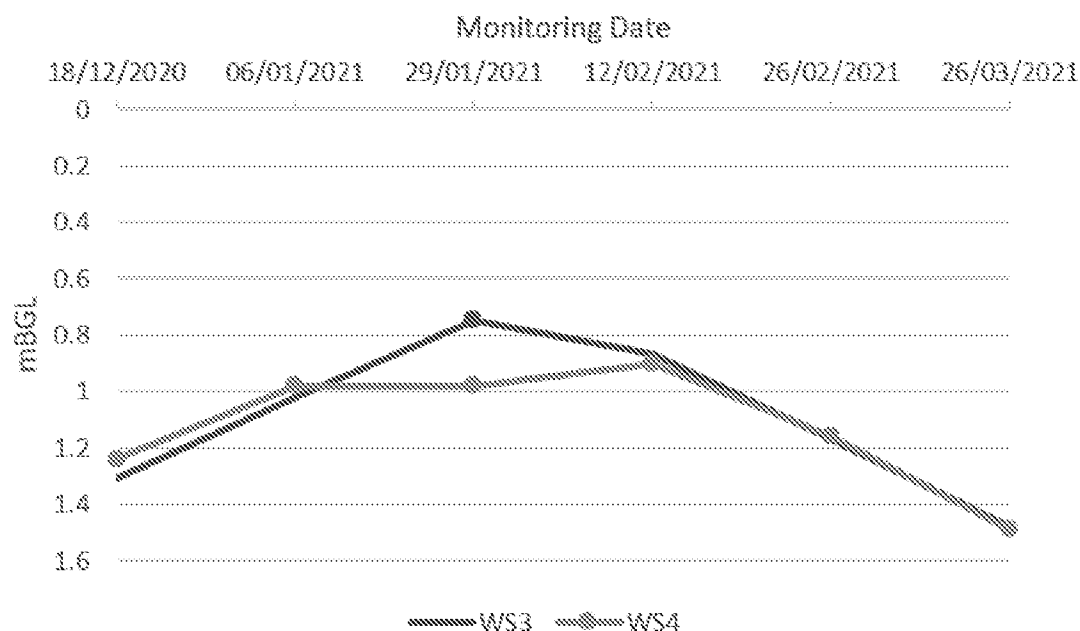


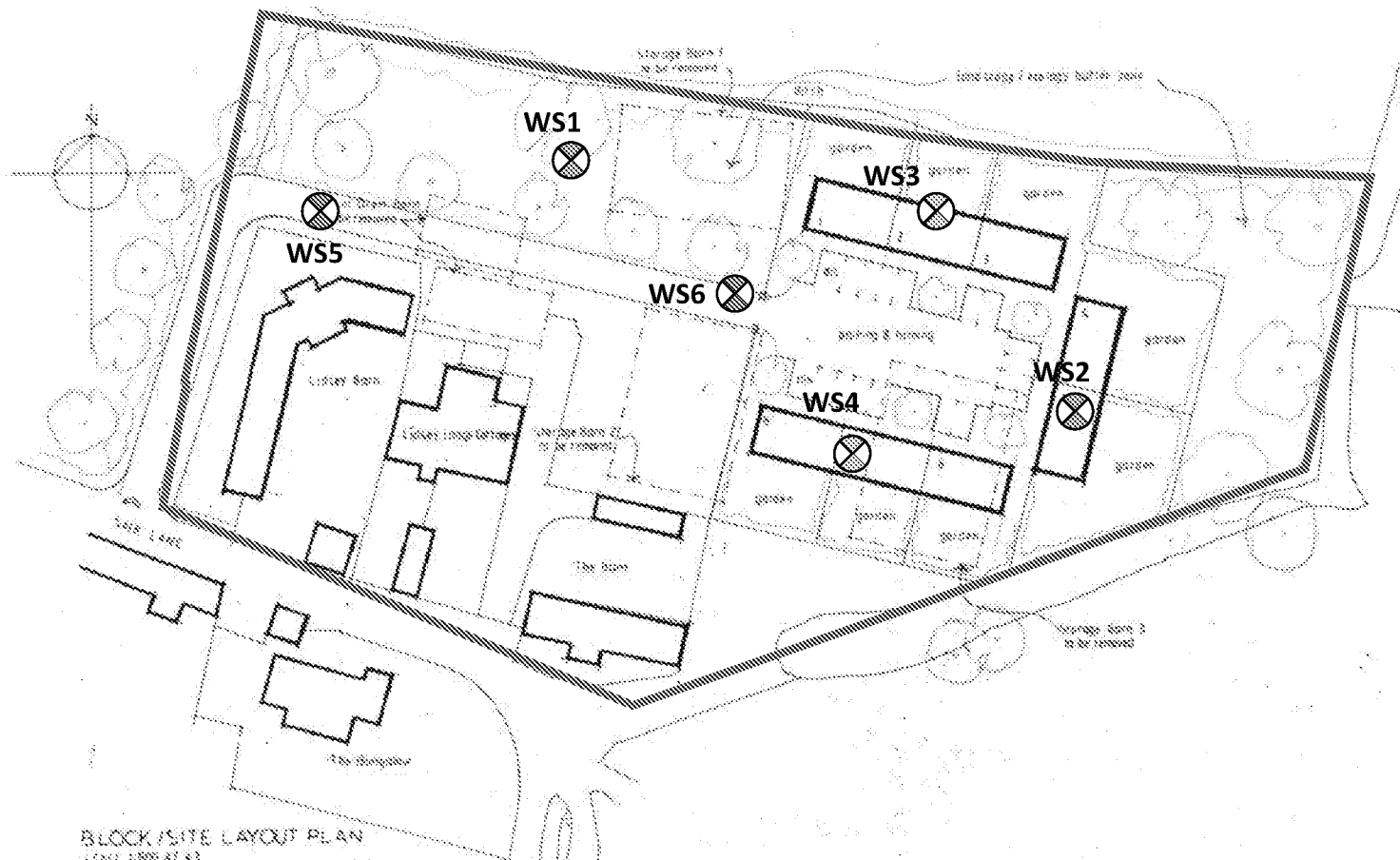
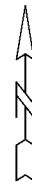
Table 2: Groundwater Strikes

Trial Hole	Date of water strike	Depth to Groundwater strike (mbGL)	Comments
WS2	18/12/20	1.6	Seepage within clay, roughly 50mm above the boundary with the chalk.
WS3		2	Seepage within clay. Rose to 1.31m after an hour.
WS4		3	Seepage within clay. Rose to 1.24m after an hour
WS6		4	Water struck at base of borehole, within chalk.

5 Groundwater Monitoring

Groundwater monitoring was undertaken from the 18th December 2020 to the 26th March 2021. The first monitoring visit took place on the day of the intrusive investigation, approximately 1 hour after the drilling had ended in order to allow groundwater levels to equalise. The elevations are shown in the chart below and full results are provided in Appendix D.

Chart 3: Summary of groundwater elevations



BLOCK/SITE LAYOUT PLAN

Scale 1:500 at A3
0 10 20 30m

RJCA Chartered Architects
The White House, 2 Lavant Road
Chichester, West Sussex PO19 5RQ
Tel: 01243 778600
Mobile: 07973435493
Email: rjcatkinsen@btinternet.com

Project Name: Lidsey Lodge Farm

Drawings: Site layout and block plan

Drawing Number: 2020/10/11 Rev. C

 Windowless sampler location

 Windowless sampler location with soakage test

 Windowless sampler location with well install



Client: RJCA on behalf of
Melanie Jenkins

Date: 31/03/21

Project ID: LP2430

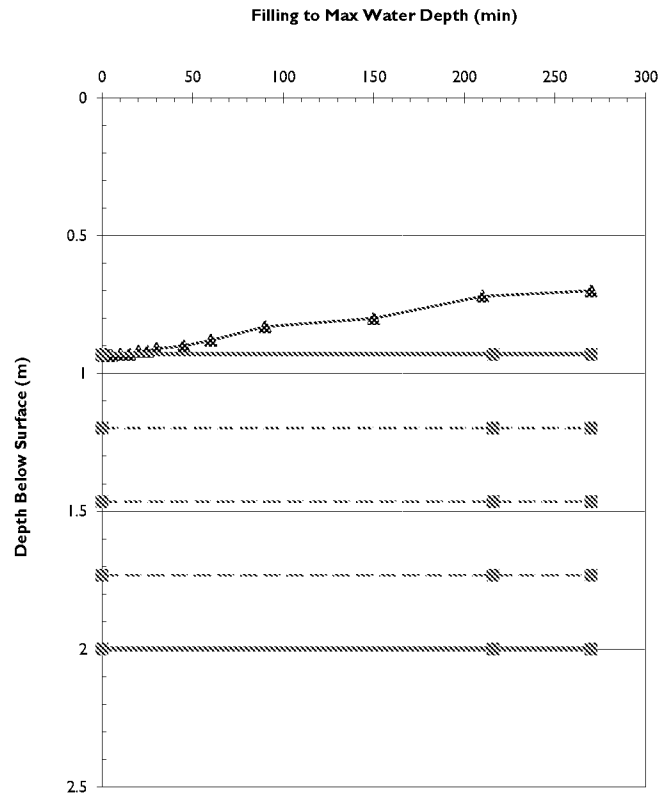
Project: Lidsey Lodge Farm

Title: SI locations

Fig. No. 2

			Groundwater Monitoring Record	
			Lidsey Lodge Farm LP2430	
			BHID	
			WS3	WS4
Engineer:	SH	Borehole Depth (m)	~3	~3
Date:	18/12/20	Water Level (m bgl)	1.31	1.24
	06/01/21	Water Level (m bgl)	1.02	0.98
	29/01/21	Water Level (m bgl)	0.75	0.98
	12/02/21	Water Level (m bgl)	0.87	0.9
	26/02/21	Water Level (m bgl)	1.17	1.16
	26/03/21	Water Level (m bgl)	1.48	1.49

BRE Digest 365 - Soakage Test



initial)

Test Hole No: WS1
Test No: Test No 1



£

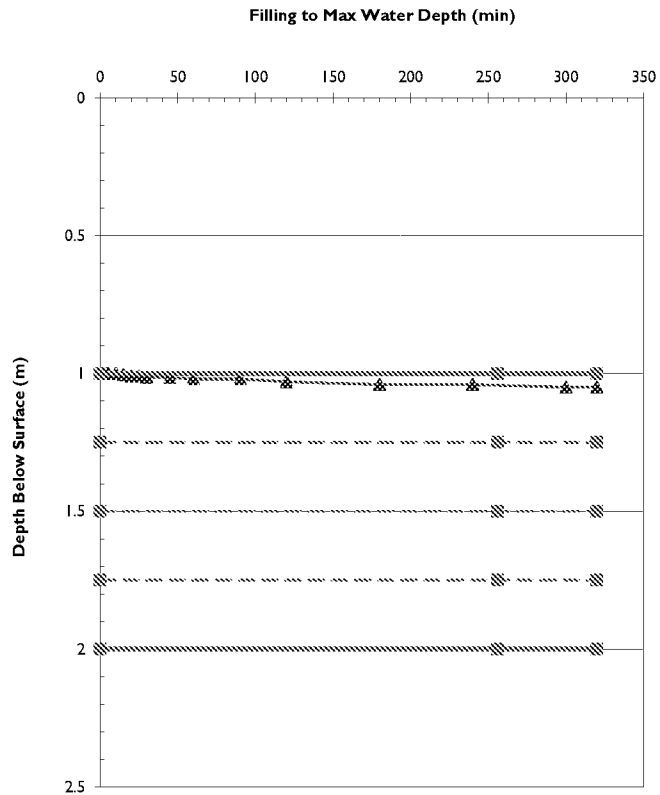
Diameter of Borehole (m)	0.101
Depth to End of Borehole Casing (m)	1
Depth to Borehole Base (m)	2
Depth to Top of Permeable Soils (m)	
Depth to Groundwater Surface (m)	
Depth to Top of Granular Fill (m)	
Voids Assumed within Borehole (%)	
Depth of Water at Start of Test (m)	0.93
Max Water Dropdown during Test (m)	0.005
Total Soakage Test Time (min)	270
Mean Internal Discharge Area (m2)	0.325313
Discharge Rate (litre/min)	
Soakage Rate (litre/m2/min)	N/A
BRE Soil Infiltration Rate (m/sec)	N/A

Comments:

Water level arose during the test, soakage rate calculation is not applicable.

Client: RJCA Chartered Architects on behalf of Melanie Jenkins
Site: Lidsey Lodge Farm, Sack Lane, Lidsey, Bognor Regis PO22 9PE
Tested By: MW/KT
Test Date: 18/12/20

BRE Digest 365 - Soakage Test



initial)

Test Hole No: WS2
Test No: Test No 1



Diameter of Borehole (m)	0.101
Depth to End of Borehole Casing (m)	1
Depth to Borehole Base (m)	2
Depth to Top of Permeable Soils (m)	
Depth to Groundwater Surface (m)	1.6
Depth to Top of Granular Fill (m)	
Voids Assumed within Borehole (%)	
Depth of Water at Start of Test (m)	1
Max Water Dropdown during Test (m)	0.05
Total Soakage Test Time (min)	320
Mean Internal Discharge Area (m2)	0.311431
Discharge Rate (litre/min)	
Soakage Rate (litre/m2/min)	
BRE Soil Infiltration Rate (m/sec)	

Comments:

Water level did not fall to 75% max water depth, calculations were based on actual fall of water level achieved. Result not compliant with BRE365 requirement since water did not fall to 25% max water depth.

Client: RJCA Chartered Architects on behalf of Melanie Jenkins
Site: Lidsey Lodge Farm, Sack Lane, Lidsey, Bognor Regis PO22 9PE
Tested By: MW/KT
Test Date: 18/12/20

Appendix D Lead Planning Authority and Lead Local Flood Authority Consultation

Dan Lytton

From: Paul Cann <Paul.Cann@arun.gov.uk>
Sent: 09 February 2021 10:59
To: Dan Lytton
Cc: Kevin Macknay
Subject: RE: D1922 - Lidsey Lodge Farm
Attachments: l33pipgdbwleo01bfejlntyk1_2.pdf; surface water flood mapping.pdf; flood map.pdf

Hi Dan

Some brief comments;

1. I have copied in WSCC just in case they wish to make additional comments.
2. Copy of our land drainage records enclosed for information.
3. The nearest known flooding is on the public highway at the junction of the A29 and Sack Lane has suffered historical flooding. There may be other areas in Sack Lane that suffer flooding but are not recorded on our records.
4. Surface water flood map (1 in 30 to 1 in 1000 year events) enclosed which indicates a low area on the site perimeter.
5. Tidal/fluvial flood map (undefended) enclosed – part of the site is within flood zone 2/3.
6. The area has high groundwater and infiltration potential is poor but must be fully investigated for any redevelopment proposal.
7. No mains drainage in Sack Lane.

Hope this helps.

Regards

Paul Cann
Principal Drainage Engineer
Engineering Services

T: 01903 737819
E: paul.cann@arun.gov.uk



Arun District Council, Civic Centre, Maltravers Rd, Littlehampton, West Sussex, BN17 5LF
www.arun.gov.uk

Sign up to our newsletter [here](#)



From: Dan Lytton <[REDACTED]>
Sent: 08 February 2021 18:00
To: Paul Cann <Paul.Cann@arun.gov.uk>
Subject: RE: D1922 - Lidsey Lodge Farm

Hi Paul,

LIDSEY LODGE FARM, SACK LANE, LIDSEY PO22 9PE

Please could you provide me with any flood risk or drainage information you may have of relevance on the attached site.

Dan Lytton

From: Kevin Macknay <kevin.macknay@westsussex.gov.uk>
Sent: 22 January 2021 15:16
To: Dan Lytton
Subject: RE: D1922 - Lidsey Lodge Farm
Attachments: EA Flood Zone 2 and 3 Mapping.pdf; Existing Road Gullies.pdf; JBA Groundwater Flood Risk Map.pdf; RoFSW Mapping_1in30 and 1in100 Mapping.pdf

Dan,

Further to your recent enquiry re. the above development. Please see my response below:

Flood Zones

- Please confirm the Flood Zones for this area.
Based on current EA mapping the area is on the boundary of both Flood Zones 2 and 3.
We would advise you to contact the EA and discuss the effect of future climate change predictions regarding this location.
- Please confirm surface water, reservoir flooding, sewer flooding. Please provide plans and depth data from your GIS UFMSW for 30yr, 100yr & 1000yr as applicable (OS Datum).
See attached plan. Generally the site is at 'Low' risk of surface water flooding. Development should be avoided within close proximity to the existing watercourses.
- Please confirm mapping and records for any surface water assets owned or maintained.
WSCC have no surface water assets owned or maintained within the confines of the site.
- Please confirm if there are any future drainage improvements proposed for this area.
None that we are aware of.
- Please confirm details of existing or planned flood alleviation and defences in this area.
None that we are aware of.
- Please confirm any existing river and/or tidal levels, for the 100yr, 100yr with climate change, 200yr, 200yr with climate change, 1000yr, and 1000yr with climate change flood events.
This information would be available from the EA.
- Please confirm any gauged flow records for river networks in close proximity to the site, with associated estimated return periods.
This information would be available from the EA. However, as the waterbodies directly adjacent to the site are 'ordinary watercourses' it is unlikely that the EA would hold any information for this area.
- Please confirm if you are aware of any historic flooding within the confines of the site.
None that we are aware of. However, you should check with the current owner and Arun District Council as the site may well have flooded in June 2012.
- Please confirm if you are aware of any historic flooding in close vicinity and/or on the public highway.
Areas adjacent to the site were affected by flooding during the June 2012 event, and subsequently. We have records of highway flooding along Sack Lane and the A29. The junction of Sack Lane and the A29 was impassable to traffic for some time following the June 2012 event.

Groundwater

- Please confirm details of any groundwater flooding issues in the area, including flood levels, flood extents and any available anecdotal information.

Base on the current JBA Groundwater Flood Risk mapping the area is at 'High' risk of groundwater flood. With groundwater either very near or within 0.025m of the ground surface. See attached plan.

- Please confirm details of aquifer designation, soil classification, and Source Protection Zones in this area. We do not hold this information. This information should be available on-line.
- Please confirm details of any surface and groundwater discharges, abstractions including private licences and pollution incidents. We do not hold this information. This information may be available from the EA.
- Please confirm details of any recorded groundwater levels in the area, and groundwater vulnerability of the area. We do not hold this information.

Policy/Future

- Please confirm any Flood Modelling data undertaken within a 1 km radius of the site. None that we are aware of.
- Please confirm details of future defence upgrades and/or shoreline management plans/policies. Future works - None that we are aware of. Policies etc. – WSCC SFRA – January 2010.

Kevin Macknay
Flood Risk Management – Team Leader
Highways, Transport and Planning
Place Services
West Sussex County Council

 CALL  IM  EMAIL

Location: Western Area Office, Drayton Lane, Nr. Chichester, West Sussex. PO20 2AJ

Contact: Internal: 26429 | External: +44 (0)330 222 6429 | Mobile: +44 (0)7540 641819

E-mail: kevin.macknay@westsussex.gov.uk

[Report a problem with a road or pavement or raise a highways related enquiry.](#)

Follow us at  [@WSHighways](#)

From: Dan Lytton <
Sent: 21 January 2021 18:51
To: Kevin Macknay <kevin.macknay@westsussex.gov.uk>
Subject: D1922 - Lidsey Lodge Farm

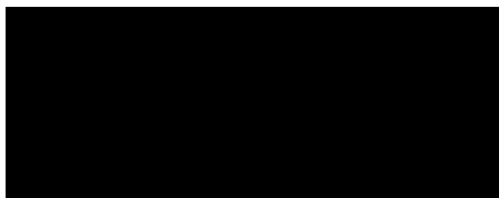
Hi Kevin,

LIDSEY LODGE FARM, SACK LANE, LIDSEY PO22 9PE

Please could you provide us with the relevant flood risk and drainage information you have on the attached site.

Kind Regards,

Dan Lytton MEng
Engineer





Fox House

Farm

Lidsey

Cherry Tree Cottages

Barn
Shipney



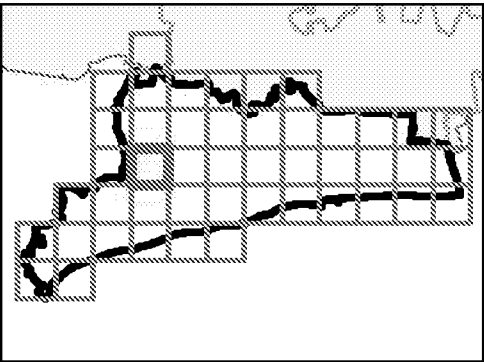
Notes

The Historic Flooding Map shows the recorded incidents and flood outlines provided by Arun District Council, West Sussex County Council, Southern Water and Environment Agency. Historical flood extent was obtained from the Environment Agency.

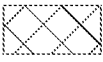
Flooding incidents provided have been categorised based upon the details provided in the records. Unknown flood points could not be determined from the information provided, and therefore could be from a number of sources.

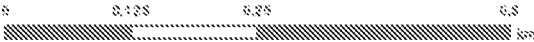
Please note that not all historical records may be shown on this map, and that it is therefore advised you contact Arun District Council for updated information post 2015.

Key Plan



Legend

-  Arun District SFRA boundary
-  Historic flood outline
- Source of flooding**
-  Fluvial
-  Coastal
-  Tidal
-  Surface Water
-  Failure
-  Unknown



REF	Date	Comments
A	June 2019	-
B		
C		

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ARUN DISTRICT COUNCIL LEVEL 1 SFRA: APPENDIX H HISTORIC FLOODING RECORDS

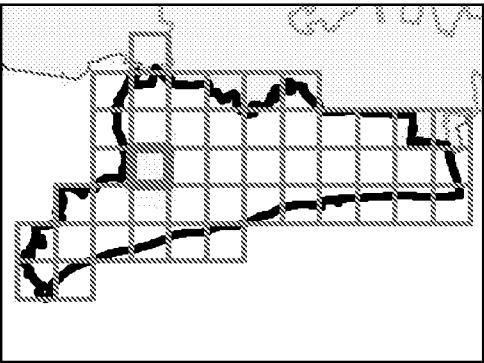
Sheet No. 21 of 48 Index Number: ADD_21

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Key Plan



Legend



Arun District SFRA boundary



Gap in Littlehampton defence

Defence type and maintainer

Embankment, Environment Agency

Embankment, Private

Embankment, Unknown

Wall, Environment Agency

Wall, Local Authority

Wall, Private

Shingle Beach, Environment Agency

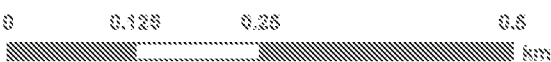
Shingle Beach, Local Authority

Shingle Beach, Littlehampton Harbour

Shingle Beach, Private

Shingle Beach, Worthing Borough

Unknown



REF	Date	Comments
A	June 2016	-
B		
C		

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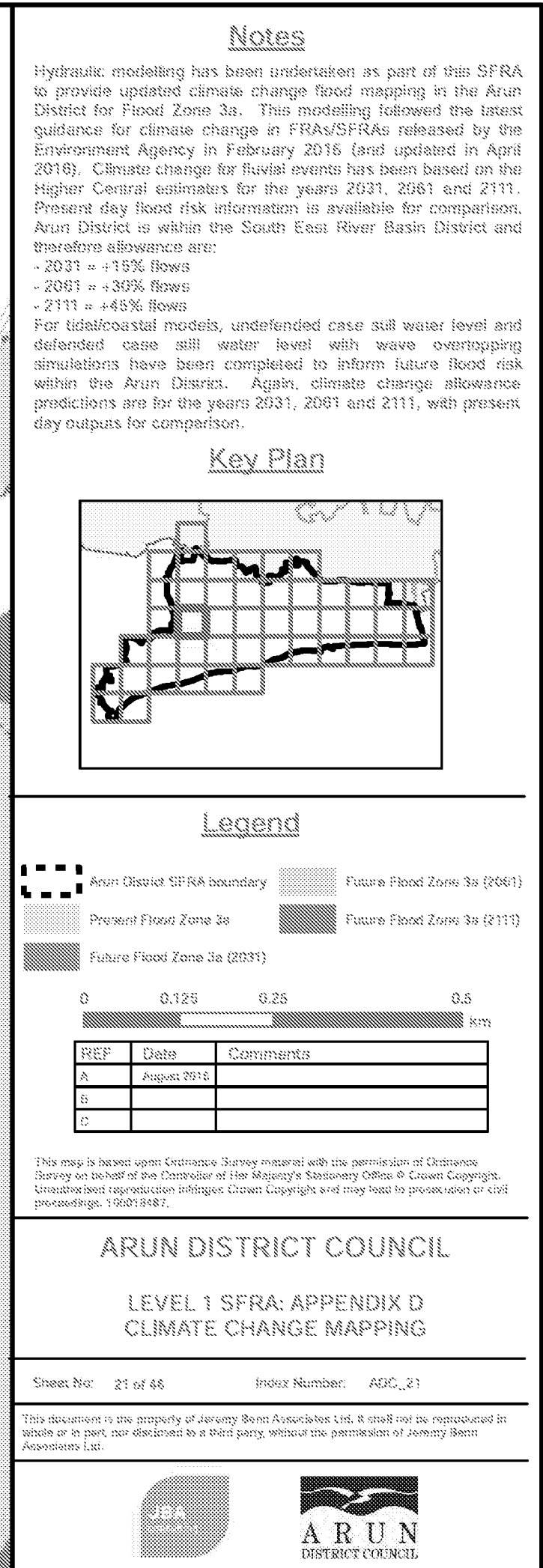
ARUN DISTRICT COUNCIL

LEVEL 1 SFRA: APPENDIX I
DEFENCES

Sheet No. 21 of 48 Index Number: ADD_21

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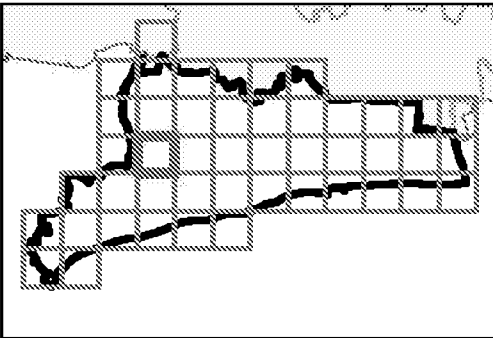
Notes

The Areas Susceptible to Groundwater Flooding (ASiGWF) is a strategic scale map showing groundwater flood areas on a 1km square grid. The data was produced to annotate indicative Flood Risk Areas for Preliminary Flood Risk Assessment (PFRA) studies and allow the Lead Local Flood Authorities (LLFAs) to determine whether there may be a risk of flooding from groundwater.

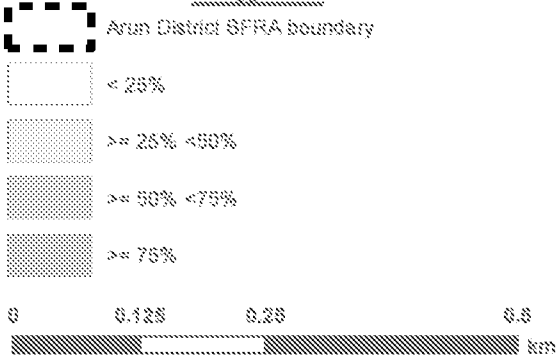
This data shows the proportion of each 1km grid square where geological and hydrogeological condition show that groundwater might emerge. It does not show the likelihood of groundwater flooding occurring. It does not take account of the chance of flooding from groundwater rebound. This dataset covers a large area of land, and only isolated locations within the overall susceptible area are actually likely to suffer the consequences of groundwater flooding.

The ASiGWF data should be used only in combination with other information, for example local data or historic data. It should not be used as sole evidence for any specific flood risk management, land use planning or other decisions at any scale. However, the data can help to identify areas for assessment at a local scale where finer resolution datasets exist.

Key Plan



Legend



REF	Date	Comments
A	June 2016	-
B		
C		

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ARUN DISTRICT COUNCIL

LEVEL 1 SFRA: APPENDIX F AREAS SUSCEPTIBLE TO GROUNDWATER

Sheet No. 21 of 48 Index Number: ADC_21

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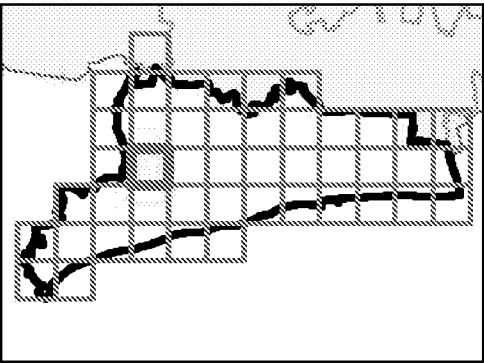
Notes

Flood Alerts are used to warn people of the possibility of flooding and encourage them to be alert, stay vigilant and make early preparations. It is issued earlier than a flood warning, to give customers advice notice of the possibility of flooding, but before we are fully confident that flooding in Flood Warning Areas is expected.

Flood Warnings warn people of expected flooding and encourage them to take action to protect themselves and their property.

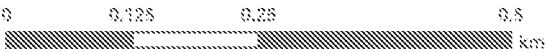
Some areas may be covered by more than one flood warning area as they may be at risk of flooding from more than one

Key Plan



Legend

	Arun District SFRA boundary		065FWF5005
	065FWC2401		065FWC2601
	065FWF4903		065FWC2602
	065FWF4904		065FWC2501
	065FWF5301		065FWF5006
	065FWF5302		065FWF4901
	065FWF5007		065FWC2402
	065FWF5008		065FWC2402



REF	Date	Comments
A	June 2016	-
B		
C		

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LEVEL 1 SFRA: APPENDIX G
FLOOD WARNING AREAS

Sheet No. 21 of 46 Index Number. ADC_21

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Appendix E Environment Agency Product 4 Response

Product 4 Flood Risk Data Requested by: Bright Plan Civils

Site: Lidsey Lodge Farm, Sack Lane, Lidsey, PO22 9PE

Table 1: Water Levels: Fluvial Undefended

Node Ref	NGR		Modelled Flood Levels in Metres AOD					
	Eastings	Northings	Undefended Annual Exceedance Probability					
			5%	1%	1% +CC (35%)	1% +CC (45%)	1% +CC (105%)	0.1%
1	494501	102617	-	-	-	-	-	-
2	494555	102638	-	-	-	-	-	-
3	494542	102574	-	-	-	-	2.20	-
4	494624	102621	-	-	-	-	-	-

Table 2: Water Levels: Fluvial Defended

Node Ref	NGR		Modelled Flood Levels in Metres AOD					
	Eastings	Northings	Defended Annual Exceedance Probability					
			5%	1%	1% +CC (35%)	1% +CC (45%)	1% +CC (105%)	0.1%
1	494501	102617	-	-	-	-	-	-
2	494555	102638	-	-	-	-	-	-
3	494542	102574	-	2.08	-	2.15	2.20	2.18
4	494624	102621	-	-	-	-	-	-

Table 3: Water Levels: Tidal Undefended

Node Ref	NGR		Modelled Flood Levels in Metres AOD			
	Eastings	Northings	Undefended Annual Exceedance Probability			
			0.5%	0.5% (2070)*	0.5% (2115)*	0.1%
1	494501	102617	-	-	3.61	-
2	494555	102638	-	2.66	3.61	-
3	494542	102574	1.97	2.66	3.61	2.14
4	494624	102621	-	-	3.61	-

Table 4: Water Levels: Tidal Defended

Node Ref	NGR		Modelled Flood Levels in Metres AOD			
	Eastings	Northings	Defended Annual Exceedance Probability			
			0.5%	0.5% (2070)*	0.5% (2115)*	0.1%
1	494501	102617	-	-	-	-
2	494555	102638	-	-	-	-
3	494542	102574	-	-	-	-
4	494624	102621	-	-	-	-

Table 5: Water Depths: Fluvial Undefended

Node Ref	NGR		Modelled Flood Depths in Metres					
	Eastings	Northings	Undefended Annual Exceedance Probability					
			5%	1%	1% +CC (35%)	1% +CC (45%)	1% +CC (105%)	0.1%
1	494501	102617	-	-	-	-	-	-
2	494555	102638	-	-	-	-	-	-
3	494542	102574	-	-	-	-	0.32	-
4	494624	102621	-	-	-	-	-	-

Table 6: Water Depths: Fluvial Defended

Node Ref	NGR		Modelled Flood Depths in Metres					
	Eastings	Northings	Defended Annual Exceedance Probability					
			5%	1%	1% +CC (35%)	1% +CC (45%)	1% +CC (105%)	0.1%
1	494501	102617	-	-	-	-	-	-
2	494555	102638	-	-	-	-	-	-
3	494542	102574	-	0.21	-	0.24	0.29	0.31
4	494624	102621	-	-	-	-	-	-

Table 7: Water Depths: Tidal Undefended

Node Ref	NGR		Modelled Flood Depths in Metres			
	Eastings	Northings	Undefended Annual Exceedance Probability			
			0.5%	0.5% (2070)*	0.5% (2115)*	0.1%
1	494501	102617	-	-	0.23	-
2	494555	102638	-	0.01	0.57	-
3	494542	102574	0.15	0.85	1.79	0.32
4	494624	102621	-	-	1.07	-

Table 8: Water Depths: Tidal Defended

Node Ref	NGR		Modelled Flood Depths in Metres			
	Eastings	Northings	Defended Annual Exceedance Probability			
			0.5%	0.5% (2070)*	0.5% (2115)*	0.1%
1	494501	102617	-	-	-	-
2	494555	102638	-	-	-	-
3	494542	102574	-	-	-	-
4	494624	102621	-	-	-	-

All levels taken from:

Fluvial: Aldingbourne Flood Risk Mapping Study, completed in 2015 by JBA Consulting (Defended only), plus climate change allowances (2016). Tidal: River Arun to East Head, completed in 2016 by JBA Consulting.

Produced on: 05/02/2021

***The flood risk data provided is based on existing EA hydraulic models for existing 0.5% annual probability events with an allowance for climate change. Please note the climate change allowances provided are not up to date. These were updated on 17 December 2019.**

You should refer to 'Flood risk assessments: climate change allowances' for the most up to date allowances. You will need to undertake further assessment of future flood risk using different allowances to ensure your assessment of future flood risk is based on best available evidence.

There is no additional information or health warnings for these levels/depths or the model from which they have been produced.

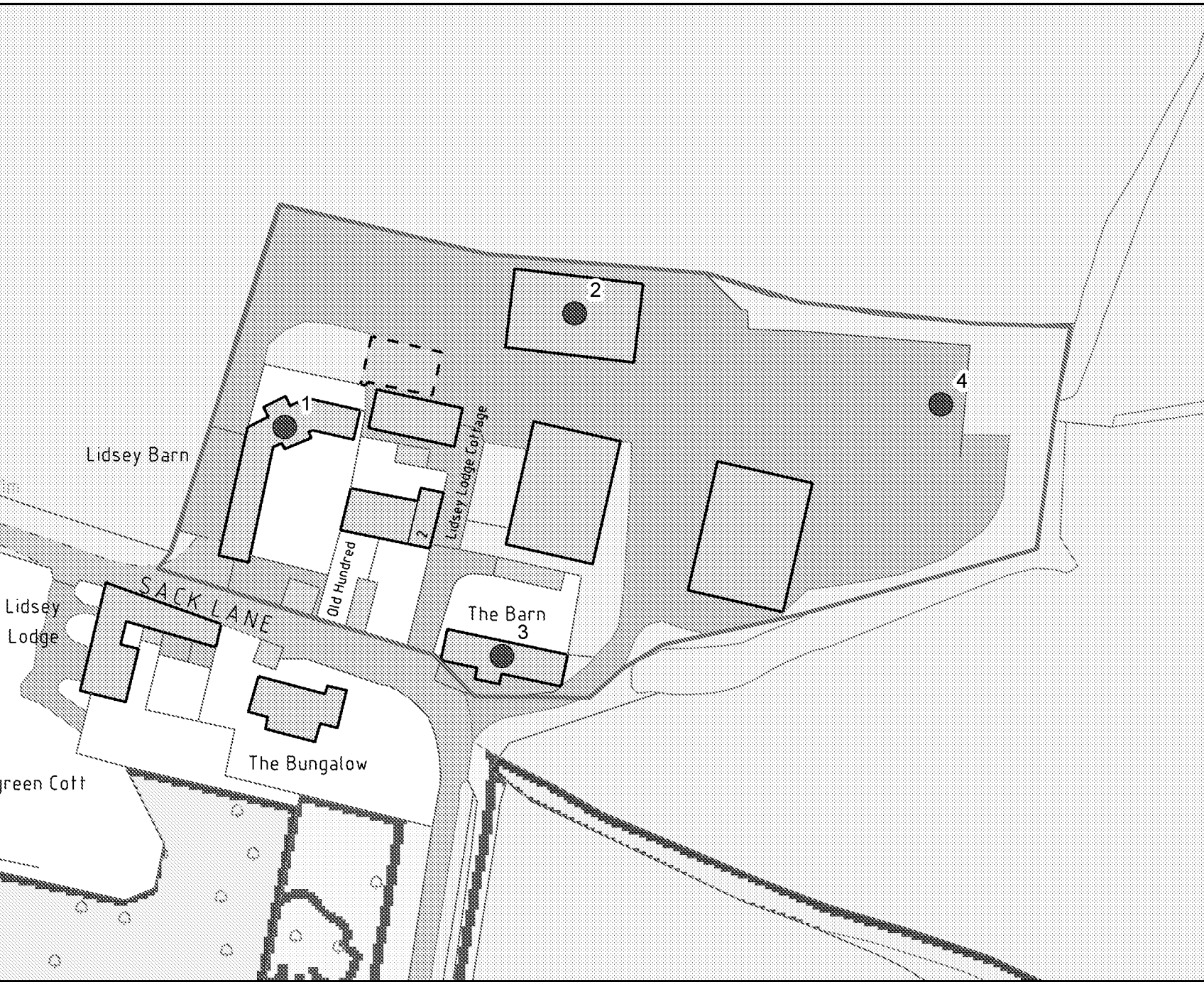
 Environment Agency

N

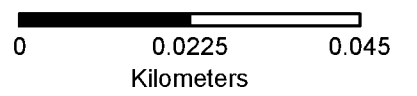

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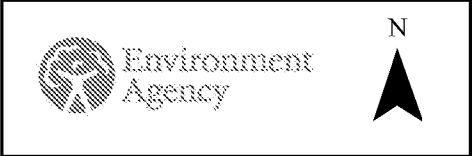
 Site_Nodes

 Site_Boundary



Scale: 1:1,000



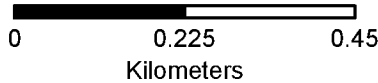


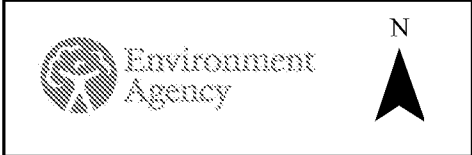
Legend

- Site_Boundary
- 1% AEP (Un defended Fluvial)
- 0.1% AEP (Un defended Fluvial)

Annual Exceedance Probability (AEP) The probability of a flood of a particular magnitude, or greater occurring in any given year.

Scale: 1:10,000

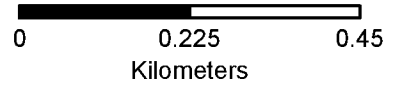


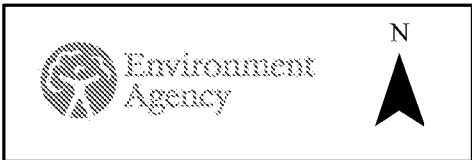


- Legend**
- Site_Boundary
 - 0.5% AEP (Defended Tidal)
 - 0.5% AEP (2070) NPPF (Defended Tidal)
 - 0.5% AEP (2115) NPPF (Defended Tidal)
 - 0.1% AEP (Defended Tidal)

Annual Exceedance Probability (AEP) The probability of a flood of a particular magnitude, or greater occurring in any given year.

Scale: 1:10,000

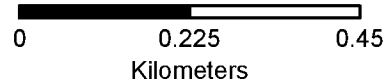




- Legend**
- Site_Boundary
 - 5% AEP (Defended Fluvial)
 - 1% AEP (Defended Fluvial)
 - 0.1% AEP (Defended Fluvial)

Annual Exceedance Probability (AEP) The probability of a flood of a particular magnitude, or greater occurring in any given year.

Scale: 1:10,000



Modelled Flood Outlines- Climate Change Allowances (Undefended Fluvial).
Centred PO22 9PE. Created 05/02/2021.





Environment
Agency

N
▲

Legend

- Site_Boundary
- 1% AEP +35% (Undefended Fluvial)
- 1% AEP +45% (Undefended Fluvial)
- 1% AEP +105% (Undefended Fluvial)

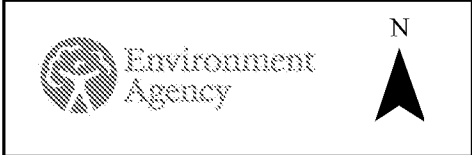
Annual Exceedance Probability (AEP) The probability of a flood of a particular magnitude, or greater occurring in any given year.

Scale: 1:10,000

00.2250.45

Kilometers

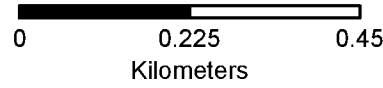
Modelled Flood Outlines- Climate Change Allowances (Defended Fluvial).
Centred PO22 9PE. Created 05/02/2021.

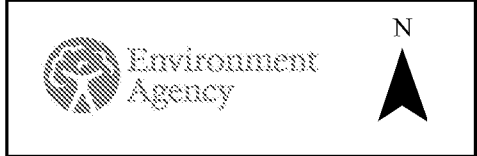


- Legend**
- Site_Boundary
 - 1% AEP +35% (Defended Fluvial)
 - 1% AEP +45% (Defended Fluvial)
 - 1% AEP +105% (Defended Fluvial)

Annual Exceedance Probability (AEP) The probability of a flood of a particular magnitude, or greater occurring in any given year.

Scale: 1:10,000



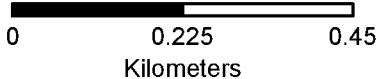


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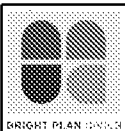
- Site_Boundary
- 0.5% AEP (Un defended Tidal)
- 0.5% AEP (2070) NPPF (Un defended Tidal)
- 0.5% AEP (2115) NPPF (Un defended Tidal)
- 0.1% AEP (Un defended Tidal)

Annual Exceedance Probability (AEP) The probability of a flood of a particular magnitude, or greater occurring in any given year.

Scale: 1:10,000



Appendix F Drainage Calculations



Design Settings

Rainfall Methodology	FSR	Maximum Time of Concentration (mins)	30.00
Return Period (years)	2	Maximum Rainfall (mm/hr)	250.0
Additional Flow (%)	10	Minimum Velocity (m/s)	0.75
FSR Region	England and Wales	Connection Type	Level Soffits
M5-60 (mm)	17.000	Minimum Backdrop Height (m)	0.200
Ratio-R	0.400	Preferred Cover Depth (m)	0.450
CV	0.750	Include Intermediate Ground	✓
Time of Entry (mins)	5.00	Enforce best practice design rules	✓

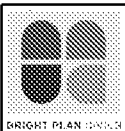
Nodes

Name	Area (ha)	T of E (mins)	Cover Level (m)	Diameter (mm)	Easting (m)	Northing (m)	Depth (m)
14	0.007	5.00	3.050	1200	494570.678	102636.424	0.550
13	0.005	5.00	3.050	1200	494609.308	102589.798	0.550
12	0.005	5.00	3.000	1200	494616.571	102620.062	0.797
11	0.007	5.00	3.050	1200	494568.361	102626.769	0.550
10	0.059	5.00	3.000	1200	494560.374	102617.246	0.965
9	0.007	5.00	3.050	1200	494562.931	102605.493	0.550
8	0.007	5.00	3.050	1200	494560.627	102595.891	0.550
7	0.007	5.00	3.000	1200	494598.316	102586.847	0.920
6	0.012	5.00	3.000	1200	494600.620	102596.448	0.976
5	0.092	5.00	3.000	1200	494603.148	102606.981	1.112
4	0.012	5.00	3.000	1200	494605.744	102617.797	1.150
3			3.000	1200	494606.847	102622.396	1.161
2	0.007	5.00	3.000	1200	494608.061	102627.452	1.174
1			2.800	1200	494609.534	102633.590	0.989

Links

Name	US Node	DS Node	Length (m)	ks (mm) / n	US IL (m)	DS IL (m)	Fall (m)	Slope (1:X)	Dia (mm)	T of C (mins)	Rain (mm/hr)
1.006	2	1	6.312	0.600	1.826	1.811	0.015	420.8	225	6.99	51.3
6.000	14	2	38.445	0.600	2.500	1.951	0.549	70.0	100	5.70	56.4
1.005	3	2	5.200	0.600	1.839	1.826	0.013	400.0	225	6.82	51.9
5.001	12	3	10.000	0.600	2.203	1.964	0.239	41.8	100	5.83	55.8
1.004	4	3	4.729	0.600	1.850	1.839	0.011	429.9	225	6.69	52.4
4.000	11	4	38.445	0.600	2.500	1.975	0.525	73.2	100	5.71	56.4
1.003	5	4	11.123	0.600	1.888	1.850	0.038	292.7	225	6.56	52.9
3.000	10	5	43.988	0.600	2.035	1.888	0.147	299.2	225	5.98	55.2
1.002	6	5	10.832	0.600	2.024	1.963	0.061	177.6	150	6.32	53.8

Name	Vel (m/s)	Cap (l/s)	Flow (l/s)	US Depth (m)	DS Depth (m)	Σ Area (ha)	Σ Add Inflow (l/s)
1.006	0.631	25.1	34.7	0.949	0.764	0.227	0.0
6.000	0.921	7.2	1.2	0.450	0.949	0.007	0.0
1.005	0.648	25.7	33.0	0.936	0.949	0.213	0.0
5.001	1.195	9.4	1.7	0.697	0.936	0.010	0.0
1.004	0.624	24.8	31.7	0.925	0.936	0.203	0.0
4.000	0.900	7.1	1.2	0.450	0.925	0.007	0.0
1.003	0.759	30.2	29.0	0.887	0.925	0.184	0.0
3.000	0.750	29.8	9.7	0.740	0.887	0.059	0.0
1.002	0.751	13.3	5.3	0.826	0.887	0.033	0.0



Links

Name	US Node	DS Node	Length (m)	ks (mm) / n	US IL (m)	DS IL (m)	Fall (m)	Slope (1:X)	Dia (mm)	T of C (mins)	Rain (mm/hr)
2.000	9	6	38.759	0.600	2.500	2.074	0.426	91.0	100	5.80	56.0
1.001	7	6	9.874	0.600	2.080	2.024	0.056	176.3	150	6.08	54.8
1.000	8	7	38.759	0.600	2.500	2.130	0.370	104.8	100	5.86	55.7
5.000	13	12	31.123	0.600	2.500	2.203	0.297	104.8	100	5.69	56.5

Name	Vel (m/s)	Cap (l/s)	Flow (l/s)	US Depth (m)	DS Depth (m)	Σ Area (ha)	Σ Add Inflow (l/s)
2.000	0.806	6.3	1.2	0.450	0.826	0.007	0.0
1.001	0.754	13.3	2.3	0.770	0.826	0.014	0.0
1.000	0.751	5.9	1.2	0.450	0.770	0.007	0.0
5.000	0.751	5.9	0.8	0.450	0.697	0.005	0.0

Pipeline Schedule

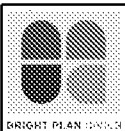
Link	Length (m)	Slope (1:X)	Dia (mm)	Link Type	US CL (m)	US IL (m)	US Depth (m)	DS CL (m)	DS IL (m)	DS Depth (m)
1.006	6.312	420.8	225	Circular	3.000	1.826	0.949	2.800	1.811	0.764
6.000	38.445	70.0	100	Circular	3.050	2.500	0.450	3.000	1.951	0.949
1.005	5.200	400.0	225	Circular	3.000	1.839	0.936	3.000	1.826	0.949
5.001	10.000	41.8	100	Circular	3.000	2.203	0.697	3.000	1.964	0.936
1.004	4.729	429.9	225	Circular	3.000	1.850	0.925	3.000	1.839	0.936
4.000	38.445	73.2	100	Circular	3.050	2.500	0.450	3.000	1.975	0.925
1.003	11.123	292.7	225	Circular	3.000	1.888	0.887	3.000	1.850	0.925
3.000	43.988	299.2	225	Circular	3.000	2.035	0.740	3.000	1.888	0.887
1.002	10.832	177.6	150	Circular	3.000	2.024	0.826	3.000	1.963	0.887
2.000	38.759	91.0	100	Circular	3.050	2.500	0.450	3.000	2.074	0.826
1.001	9.874	176.3	150	Circular	3.000	2.080	0.770	3.000	2.024	0.826
1.000	38.759	104.8	100	Circular	3.050	2.500	0.450	3.000	2.130	0.770
5.000	31.123	104.8	100	Circular	3.050	2.500	0.450	3.000	2.203	0.697

Link	US Node	Dia (mm)	Node Type	MH Type	DS Node	Dia (mm)	Node Type	MH Type
1.006	2	1200	Manhole	Adoptable	1	1200	Manhole	Adoptable
6.000	14	1200	Manhole	Adoptable	2	1200	Manhole	Adoptable
1.005	3	1200	Manhole	Adoptable	2	1200	Manhole	Adoptable
5.001	12	1200	Manhole	Adoptable	3	1200	Manhole	Adoptable
1.004	4	1200	Manhole	Adoptable	3	1200	Manhole	Adoptable
4.000	11	1200	Manhole	Adoptable	4	1200	Manhole	Adoptable
1.003	5	1200	Manhole	Adoptable	4	1200	Manhole	Adoptable
3.000	10	1200	Manhole	Adoptable	5	1200	Manhole	Adoptable
1.002	6	1200	Manhole	Adoptable	5	1200	Manhole	Adoptable
2.000	9	1200	Manhole	Adoptable	6	1200	Manhole	Adoptable
1.001	7	1200	Manhole	Adoptable	6	1200	Manhole	Adoptable
1.000	8	1200	Manhole	Adoptable	7	1200	Manhole	Adoptable
5.000	13	1200	Manhole	Adoptable	12	1200	Manhole	Adoptable



Manhole Schedule

Node	Easting (m)	Northing (m)	CL (m)	Depth (m)	Dia (mm)	Connections	Link	IL (m)	Dia (mm)
14	494570.678	102636.424	3.050	0.550	1200		0	6.000	2.500 100
13	494609.308	102589.798	3.050	0.550	1200		0	5.000	2.500 100
12	494616.571	102620.062	3.000	0.797	1200		1	5.000	2.203 100
11	494568.361	102626.769	3.050	0.550	1200		0	5.001	2.203 100
10	494560.374	102617.246	3.000	0.965	1200		0	4.000	2.500 100
9	494562.931	102605.493	3.050	0.550	1200		0	3.000	2.035 225
8	494560.627	102595.891	3.050	0.550	1200		0	2.000	2.500 100
7	494598.316	102586.847	3.000	0.920	1200		1	1.000	2.130 100
6	494600.620	102596.448	3.000	0.976	1200		1	1.001	2.080 150
5	494603.148	102606.981	3.000	1.112	1200		2	2.000	2.074 100
4	494605.744	102617.797	3.000	1.150	1200		1	1.001	2.024 150
3	494606.847	102622.396	3.000	1.161	1200		0	1.002	2.024 150
2	494608.061	102627.452	3.000	1.174	1200		1	1.003	1.888 225
							2	1.002	1.963 150
							0	1.003	1.888 225
							1	4.000	1.975 100
							2	1.003	1.850 225
							0	1.004	1.850 225
							1	5.001	1.964 100
							2	1.004	1.839 225
							0	1.005	1.839 225
							1	6.000	1.951 100
							2	1.005	1.826 225
							0	1.006	1.826 225



Manhole Schedule

Node	Easting (m)	Northing (m)	CL (m)	Depth (m)	Dia (mm)	Connections	Link	IL (m)	Dia (mm)
1	494609.534	102633.590	2.800	0.989	1200	1	1.006	1.811	225



Simulation Settings

Rainfall Methodology	FSR	Analysis Speed	Normal
FSR Region	England and Wales	Skip Steady State	x
M5-60 (mm)	17.000	Drain Down Time (mins)	240
Ratio-R	0.400	Additional Storage (m ³ /ha)	20.0
Summer CV	0.750	Check Discharge Rate(s)	x
Winter CV	0.840	Check Discharge Volume	x

Storm Durations

15 30 60 120 180 240 360 480 600 720 960 1440

Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)
1	0	0	0
30	0	0	0
100	40	10	0

Node 2 Online Hydro-Brake® Control

Flap Valve	x	Objective	(HE) Minimise upstream storage
Replaces Downstream Link	✓	Sump Available	✓
Invert Level (m)	1.826	Product Number	CTL-SHE-0064-2000-1250-2000
Design Depth (m)	1.250	Min Outlet Diameter (m)	0.100
Design Flow (l/s)	2.0	Min Node Diameter (mm)	1200

Node 5 Carpark Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Invert Level (m)	2.440	Slope (1:X)	820.0
Side Inf Coefficient (m/hr)	0.00000	Time to half empty (mins)		Depth (m)	0.400
Safety Factor	2.0	Width (m)	16.700	Inf Depth (m)	
Porosity	0.32	Length (m)	41.000		

Node 10 Carpark Storage Structure

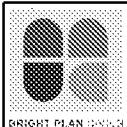
Base Inf Coefficient (m/hr)	0.00000	Invert Level (m)	2.490	Slope (1:X)	733.0
Side Inf Coefficient (m/hr)	0.00000	Time to half empty (mins)		Depth (m)	0.400
Safety Factor	2.0	Width (m)	5.400	Inf Depth (m)	
Porosity	0.32	Length (m)	110.000		



Results for 1 year Critical Storm Duration. Lowest mass balance: 95.94%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute winter	14	11	2.522	0.022	0.8	0.0310	0.0000	OK
15 minute winter	13	11	2.521	0.021	0.6	0.0281	0.0000	OK
120 minute winter	12	100	2.481	0.278	1.3	0.3496	0.0000	SURCHARGED
15 minute winter	11	11	2.523	0.023	0.8	0.0314	0.0000	OK
120 minute winter	10	102	2.481	0.446	2.4	1.0510	0.0000	SURCHARGED
15 minute winter	9	11	2.524	0.024	0.8	0.0329	0.0000	OK
15 minute winter	8	11	2.524	0.024	0.8	0.0339	0.0000	OK
120 minute winter	7	100	2.481	0.401	1.3	0.5149	0.0000	SURCHARGED
120 minute winter	6	102	2.481	0.457	2.0	0.6297	0.0000	SURCHARGED
120 minute winter	5	102	2.481	0.593	5.9	5.4002	0.0000	SURCHARGED
120 minute winter	4	104	2.481	0.631	4.2	0.8458	0.0000	SURCHARGED
120 minute winter	3	102	2.482	0.643	3.3	0.7268	0.0000	SURCHARGED
120 minute winter	2	100	2.481	0.655	2.6	0.8189	0.0000	SURCHARGED
15 minute summer	1	1	1.811	0.000	1.7	0.0000	0.0000	OK

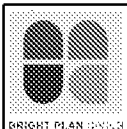
Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
15 minute winter	14	6.000	2	0.8	0.428	0.110	0.1755	
15 minute winter	13	5.000	12	0.6	0.445	0.100	0.1370	
120 minute winter	12	5.001	3	-0.9	0.477	-0.092	0.0782	
15 minute winter	11	4.000	4	0.8	0.422	0.112	0.1759	
120 minute winter	10	3.000	5	2.0	0.186	0.066	1.7494	
15 minute winter	9	2.000	6	0.8	0.504	0.123	0.1791	
15 minute winter	8	1.000	7	0.8	0.504	0.131	0.1797	
120 minute winter	7	1.001	6	-0.8	0.246	-0.060	0.1738	
120 minute winter	6	1.002	5	-1.3	0.360	-0.100	0.1907	
120 minute winter	5	1.003	4	3.4	0.311	0.111	0.4424	
120 minute winter	4	1.004	3	3.3	0.288	0.131	0.1881	
120 minute winter	3	1.005	2	2.1	0.357	0.080	0.2068	
120 minute winter	2	Hydro-Brake®	1	1.7				24.9



Results for 30 year Critical Storm Duration. Lowest mass balance: 95.94%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
240 minute winter	14	232	2.597	0.097	0.4	0.1346	0.0000	OK
240 minute winter	13	236	2.597	0.097	0.3	0.1275	0.0000	OK
180 minute winter	12	176	2.597	0.394	1.1	0.4953	0.0000	SURCHARGED
180 minute winter	11	176	2.597	0.097	0.5	0.1348	0.0000	OK
180 minute winter	10	176	2.597	0.562	4.0	8.6359	0.0000	SURCHARGED
180 minute winter	9	176	2.597	0.097	0.5	0.1349	0.0000	OK
180 minute winter	8	176	2.597	0.097	0.5	0.1350	0.0000	OK
180 minute winter	7	176	2.597	0.517	1.1	0.6637	0.0000	SURCHARGED
180 minute winter	6	176	2.597	0.573	2.1	0.7894	0.0000	SURCHARGED
180 minute winter	5	176	2.597	0.709	11.8	30.9408	0.0000	SURCHARGED
180 minute winter	4	176	2.597	0.747	4.1	1.0014	0.0000	SURCHARGED
240 minute winter	3	240	2.597	0.758	3.0	0.8576	0.0000	SURCHARGED
180 minute winter	2	180	2.597	0.771	2.6	0.9637	0.0000	SURCHARGED
15 minute summer	1	1	1.811	0.000	1.7	0.0000	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
240 minute winter	14	6.000	2	0.4	0.326	0.055	0.2996	
240 minute winter	13	5.000	12	0.3	0.261	0.051	0.2425	
180 minute winter	12	5.001	3	-0.7	0.479	-0.079	0.0782	
180 minute winter	11	4.000	4	0.5	0.321	0.067	0.2997	
180 minute winter	10	3.000	5	3.4	0.190	0.113	1.7494	
180 minute winter	9	2.000	6	0.5	0.299	0.075	0.3022	
180 minute winter	8	1.000	7	0.5	0.321	0.081	0.3022	
180 minute winter	7	1.001	6	0.9	0.211	0.066	0.1738	
180 minute winter	6	1.002	5	2.0	0.341	0.152	0.1907	
180 minute winter	5	1.003	4	3.3	0.322	0.110	0.4424	
180 minute winter	4	1.004	3	3.2	0.308	0.128	0.1881	
240 minute winter	3	1.005	2	2.0	0.336	0.077	0.2068	
180 minute winter	2	Hydro-Brake®	1	1.7				38.8



Results for 100 year +40% CC +10% A Critical Storm Duration. Lowest mass balance: 95.94%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
360 minute winter	14	352	2.772	0.272	0.6	0.3841	0.0000	FLOOD RISK
360 minute winter	13	352	2.772	0.272	0.4	0.3622	0.0000	FLOOD RISK
360 minute winter	12	352	2.772	0.569	0.8	0.7220	0.0000	FLOOD RISK
360 minute winter	11	352	2.772	0.272	0.6	0.3844	0.0000	FLOOD RISK
360 minute winter	10	352	2.773	0.738	7.6	41.2635	0.0000	FLOOD RISK
360 minute winter	9	352	2.773	0.273	0.6	0.3847	0.0000	FLOOD RISK
360 minute winter	8	352	2.773	0.273	0.6	0.3848	0.0000	FLOOD RISK
360 minute winter	7	352	2.773	0.693	1.1	0.8990	0.0000	FLOOD RISK
360 minute winter	6	352	2.773	0.749	2.6	1.0487	0.0000	FLOOD RISK
360 minute winter	5	352	2.772	0.884	11.7	69.9813	0.0000	FLOOD RISK
360 minute winter	4	352	2.772	0.922	2.7	1.2553	0.0000	FLOOD RISK
360 minute winter	3	352	2.773	0.934	2.4	1.0564	0.0000	FLOOD RISK
360 minute winter	2	352	2.772	0.946	2.2	1.1939	0.0000	FLOOD RISK
15 minute summer	1	1	1.811	0.000	1.7	0.0000	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
360 minute winter	14	6.000	2	0.5	0.325	0.075	0.3008	
360 minute winter	13	5.000	12	0.4	0.261	0.062	0.2435	
360 minute winter	12	5.001	3	0.7	0.479	0.078	0.0782	
360 minute winter	11	4.000	4	0.5	0.321	0.076	0.3008	
360 minute winter	10	3.000	5	-2.9	0.183	-0.096	1.7494	
360 minute winter	9	2.000	6	0.5	0.299	0.086	0.3033	
360 minute winter	8	1.000	7	0.5	0.284	0.092	0.3033	
360 minute winter	7	1.001	6	1.1	0.208	0.082	0.1738	
360 minute winter	6	1.002	5	2.6	0.358	0.195	0.1907	
360 minute winter	5	1.003	4	2.2	0.328	0.074	0.4424	
360 minute winter	4	1.004	3	2.4	0.290	0.096	0.1881	
360 minute winter	3	1.005	2	1.8	0.167	0.070	0.2068	
360 minute winter	2	Hydro-Brake®	1	1.8				59.5