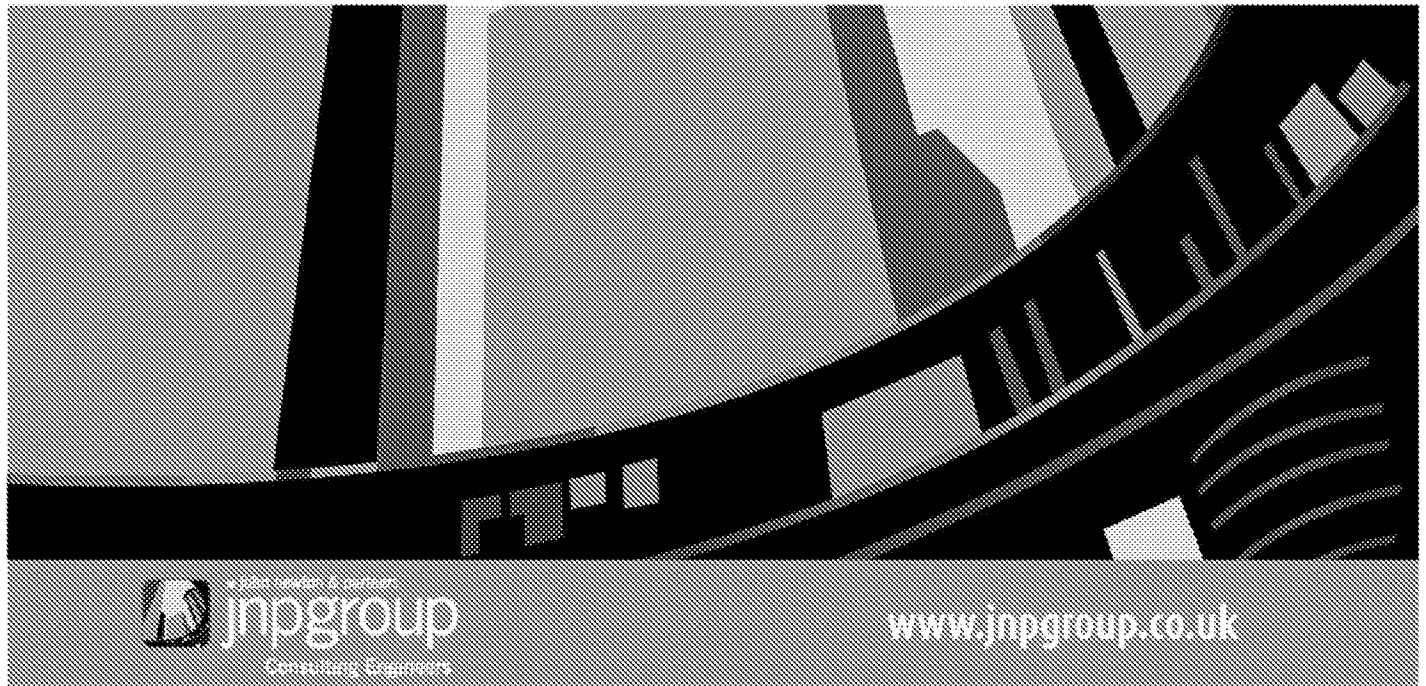


FLOOD RISK ASSESSMENT AND DRAINAGE STRATEGY



jnpgroup
Consulting Engineers

www.jnpgroup.co.uk

Flood Risk Assessment and Drainage Strategy

Project:

Ford Airfield

Client:

Redrow Homes & Wates Developments

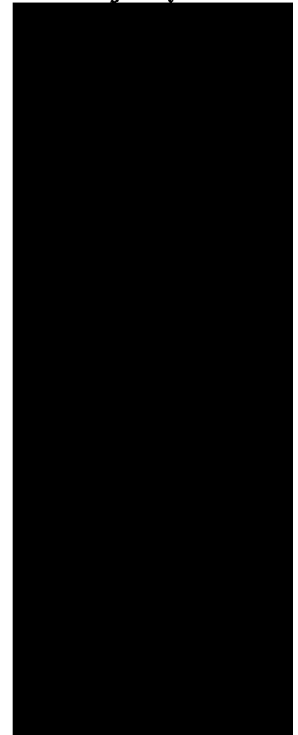
Reference:

C85228 / R001E

Date:

14 February 2020

Leamington Spa



DOCUMENT CONTROL SHEET

Flood Risk Assessment and Drainage Strategy

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Date: February 20

Document Issue Record

Rev	Date	Description	Prepared	Approved	Approved
A	17.07.19	First Issue	AM	AB	AB
B	21.08.19	Masterplan updated	AM	AB	AB
C	24.10.19	Masterplan updated	AM	AB	AB
D	19.12.19	Masterplan updated	AM	AB	AB
E	14.02.20	Groundwater information updated	AM	AB	AM

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1 EXECUTIVE SUMMARY

- 1.1 This Flood Risk Assessment (FRA) and Drainage strategy supports an outline planning application (with all matters reserved except for access) for the development of up to 1,500 dwellings (Use Class C3), 60-bed care home (Use Class C2), up to 9,000 sqm of employment floorspace (Use Classes B1), local centre of up to 2,350 sqm including up to 900 sqm retail / commercial (Use Classes A1-A5) and 1,450 sqm community / leisure floorspace (Use Classes D1-D2), land for a two-form entry primary school (Use Class D1), public open space, allotments, new sports pitches and associated facilities, drainage, parking and associated access, infrastructure, landscape, ancillary and site preparation works, including demolition of existing buildings and part removal of existing runway hardstanding.
- 1.2 The Ford Airfield development site is an allocated strategic housing site (Reference SD8) in the adopted Arun Local Plan 2011- 2031 (July 2018).
- 1.3 The existing site includes 6 hectares (ha) of infrastructure comprising of airfield runways, hard surfacing and buildings and 80.63 ha of agricultural fields and scrub.
- 1.4 The site has a low flood risk. A flood risk assessment has been carried out for Fluvial, Tidal, Surface Water, Groundwater, Sewerage and Reservoir flooding.
- 1.5 The existing infrastructure at the development site discharges surface water by gravity sewers to the River Arun and Ryebank Rife main river.
- 1.6 The drainage strategy prioritises where surface water is discharged in accordance with CIRIA SuDS Manual C753 and the following hierarchy:
-  Infiltration
 -  Discharge to watercourse
 -  Discharge to surface water sewers
- 1.7 A site investigation which comprised of boreholes, trial holes, deep soakaway testing and groundwater monitoring shows slow/ marginal infiltration rates were recorded in the east with no infiltration across the remainder of the site. Shallow groundwater was recorded in the south of the site. Therefore, deep infiltration techniques, such as soakaway chambers, are not suitable.
- 1.8 Where possible shallow infiltration SuDS components will be used. If necessary, overflows from the shallow infiltration components into the surface water sewerage network will be provided to ensure flooding does not occur onsite during prolonged storm events.
- 1.9 Further testing will be carried out to determine if shallow infiltration techniques, such as permeable paving, can be used as part of the drainage solution. However, based on the site investigation information it is considered shallow infiltration alone will not be suitable to serve the entire development for the 100 year + 40% CC storm event.
- 1.10 The development requires surface water to discharge to onsite attenuation basins which discharge to watercourse at Greenfield runoff rate (Q_{bar}).
- 1.11 During conceptual design of the development the most suitable locations for the attenuation basins were assessed based on reviewing the existing drainage and outfalls which serve the site and other relevant parameters and constraints. This informed the development of the masterplan.
- 1.12 The surface water sewers and attenuation basins have been sized to receive surface water runoff from

all impermeable areas across the site. This is currently based on the worst case with no water infiltrating into the ground. Where shallow infiltration is feasible this will enable water to discharge into the ground where it falls and may allow the attenuation basins to reduce in size.

- 1.13 The drainage strategy provides water quality treatment in accordance with the CIRIA SuDS Manual C753. The proposed site levels have been designed to ensure that any surface water exceedance flows are routed overland to areas of lesser risk such as greenspaces.
- 1.14 The drainage strategy for the development demonstrates that the proposal is flood resilient and flood risk can be safely managed.

2 INTRODUCTION

- 2.1 JNP Group (JNP) were commissioned by Redrow Homes and Wates Developments to provide a FRA and Drainage Strategy for the proposed development of land at Ford Airfield, Arundel, West Sussex.
- 2.2 The development will comprise of up to 1,500 dwellings (Use Class C3), 60-bed care home (Use Class C2), up to 9,000 sqm of employment floorspace (Use Classes B1), local centre of up to 2,350 sqm including up to 900 sqm retail / commercial (Use Classes A1-A5) and 1,450 sqm community / leisure floorspace (Use Classes D1-D2), land for a two-form entry primary school (Use Class D1), public open space, allotments, new sports pitches and associated facilities, drainage, parking and associated access, infrastructure, landscape, ancillary and site preparation works, including demolition of existing buildings and part removal of existing runway hardstanding.
- 2.3 This report is based on information available from the Environment Agency (EA), Southern Water (SW), West Sussex County Council (WSCC), Arun District Council (ADC) and information available within the public domain, including the Strategic Flood Risk Assessment (SFRA) Final Report by JBA Consulting (November 2016) commissioned by ADC.
- 2.4 The Ford Airfield development site is an allocated strategic housing site (Reference SD8) in the adopted Arun Local Plan 2011- 2031 (July 2018).
- 2.5 This report aims to manage flood risk issues for new developments in accordance with the requirements of The National Planning Policy Framework (NPPF) and ensure that there is no increase in flood risk both onsite and offsite as a result of the proposed development.

3 LOCATION AND SITE DESCRIPTION

- 3.1 The site is located west of Ford Road, Ford, Arundel, West Sussex, BN18 0FL at approximate National Grid Reference SU 996 027. The site location is shown in Figure 1 below. The Ordnance Survey coordinates for the site are

 E499211

 N102986

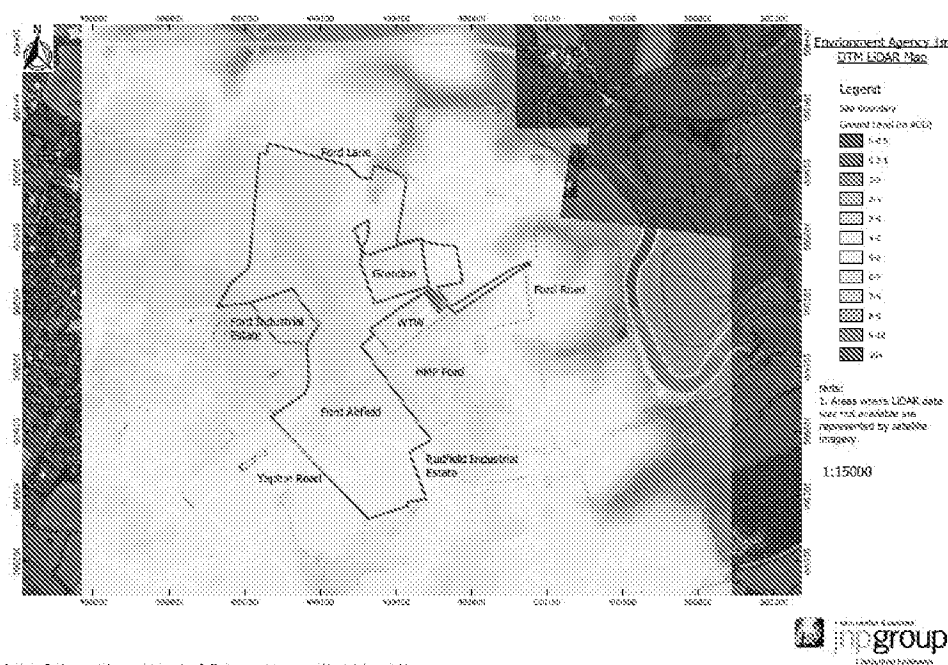


*Fig 1 Site Location. Not to Scale.
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- 3.2 The site covers an area of 86.63 ha. It has an impermeable area of approximately 6 ha comprising former airfield runways, hardstandings and existing buildings. The remaining 80.63 ha is agricultural fields or woodland/ scrub.
- 3.3 The site has 2 no. vehicular entrances. The entrance from Ford Road is located on the eastern site

boundary and the entrance from Yapton Road is located on the western site boundary. It is a former airfield which is currently used as a weekly market and car boot sale venue.

- 3.4 Within the site boundary is the existing Arun Sports Arena and the Flying Fortress indoor children's play facility. Both will be retained as part of the new development and connected into the proposed new onsite drainage systems.
- 3.5 Immediately east of the development site is Southern Water's Ford Wastewater Treatment Works, the Grundon Waste Management site and the Ford Materials Recycling Facility. Ford Airfield Industrial Estate lies to the west and Rudford Industrial Estate to the south.
- 3.5.1 1m resolution Digital Terrain Model (DTM) LiDAR data has been provided by the EA: enabling a review of the wider topography around the proposed development site. A map created from this data is provided below in Figure 2.



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Fig 2 EA 1m DTM LiDAR Map. Not to scale.

- 3.6 The site and surrounding area is defined by the River Arun valley which lies east of the site. The site and surrounding area fall towards the River Arun from west to east. However, the southern end of the site and the surrounding land on Figure 2 fall southwards towards the coast, approximately 2km past the site boundary.
- 3.7 Onsite ground levels fall from the west (7.5m AOD) to the east (5.0m AOD) with a site gradient of 1 in 550 and north (6.5m AOD) to south (4.5m AOD) with a site gradient of 1 in 800.
- 3.8 Generally, the majority of the site is gently sloping or flat with gradients in the region of 1 in 100 which rise and fall across the site. A topographical survey drawing of the site is provided in Appendix A.

4 GEOLOGY

- 4.1 British Geological Survey (BGS) maps show that the bedrock geology onsite comprises of Lewes Nodular, Seaford, Newhaven, Culver and Portsdown Chalk Formations. Superficial geology of River Terrace Deposits, comprising of sand, silt and clay are shown towards the surface of the site. The geological map also indicates that Raised Beach Deposits, which are a combination of sand and gravel, are present along the eastern boundary of the site. The estimated thickness of the superficial deposits is 3 to 4m deep.
- 4.2 A Geo- environmental and Geotechnical Site Investigation was carried out by RSK Environmental Limited (RSK) in August 2018. The findings are provided in RSK's Geo- environmental and Geotechnical Site Assessment Report, Report Reference 29228-R01 (00), dated 06 November 2018. The report provides findings based on an intrusive site investigation consisting of 6 no. deep boreholes and 10 no. shallow boreholes, 56 no. trial pits, concrete coring across the former runway and soil infiltration tests with laboratory analysis of soil samples.
- 4.3 The findings of the site investigation report which relate to the drainage strategy for the development are discussed in more detail in Section 10.

5 HYDROLOGY AND HYDROGEOLOGY

5.1 Hydrology

- 5.1.1 The River Arun lies 0.5km east of the development site.
- 5.1.2 A large deep channel is located adjacent to the site entrance off Ford Road. The channel enters a culvert under Ford Road and then flows eastwards as an open channel watercourse to the River Arun.
- 5.1.3 A second tributary of the River Arun is located off Ford Lane along the northern boundary of the site. A small pond located onsite connects into this watercourse via a sewer which crosses Ford Lane.
- 5.1.4 2 no. ordinary watercourses, which are tributaries of the Ryebank Rife main river, are located west of the site. They both receive incoming surface water connections from Ford Airfield and are located:
 -  In the field opposite the site entrance off Yapton Road approximately 38m from the site boundary,
 -  In Northwood Farm off Yapton Road, opposite the road junction with Horsemere Green Lane approximately 28m from the site boundary.
- 5.1.5 The watercourses and sewer connections have been traced as part of a detailed drainage investigation of the existing site, which is discussed in Section 6 below and are shown on the topographical survey provided in Appendix A.

5.2 Hydrogeology

- 5.3 The EA aquifer classification system designates the superficial deposits across the site as Secondary A aquifer meaning the soils could support local water supply.
- 5.4 The chalk bedrock underlying the site is classified as a principal aquifer meaning that it may support water on a strategic scale.
- 5.5 The site is not within a groundwater source protection zone as defined by the EA.
- 5.6 The 2016 Strategic Flood Risk Assessment (SFRA) for ADC shows the majority of the site to be <25% susceptible to groundwater flooding. It is noted that the groundwater susceptibility drawing does not show the likelihood of flooding but assesses geological and hydrogeological conditions to estimate areas where groundwater water might emerge.
- 5.7 The historic flooding records map in the 2016 SFRA for ADC shows no records of groundwater flooding onsite.
- 5.8 Further, site specific groundwater assessment was carried out by RSK Environment Ltd (RSK) in November 2018 as part of the Geo-Environmental and Geotechnical Site Assessment. This includes groundwater monitoring onsite undertaken for more than 12 months to establish changes in groundwater. The findings over the 2018/2019 and 2020 winter period are discussed in more detail in Section 10.6 below.

6 EXISTING SURFACE WATER FEATURES

6.1 Existing Drainage Outfalls Which Serve Ford Airfield

Drainage Tracing and CCTV Surveying Carried out by CD Surveys in January 2019

6.1.1 Extensive drainage tracing and CCTV surveying of the existing surface water sewers which serve Ford Airfield has been carried out. Please refer to the CD Surveys Drawings listed below contained in Appendix A.

6.1.2 The following drainage systems and outfalls are highlighted and have been annotated on the drawings:

Drawing BW/1812008/1 – Underground CCTV Survey Sheet 1 of 5

6.1.3 This drawing shows the existing surface water gullies and foul water sewers which serve The Flying Fortress and Arun Sports Arena. Both buildings will connect into the new drainage systems which will serve the proposed development.

Drawing BW/1812008/2 – Underground CCTV Survey Sheet 2 of 5

6.1.4 This drawing shows the surface water sewers which serve the Ford Materials Recycling Facility which is located to the south of the development site. It will not be affected by the Ford Airfield development. The sewers, 675mm and 375mm diameter, have an unrestricted discharge into a large deep channel which is located adjacent to the entrance to the Ford Airfield off Ford Road.

6.1.5 The channel discharges to the River Arun approximately 0.5 km east of the development site. The outfall from the channel is shown on drawing BW/1812008/8.

6.1.6 It is proposed to discharge the majority of the Ford Airfield development site to the existing drainage channel. Flows will be restricted to Greenfield runoff rate.

Drawing BW/1812008/3 – Underground CCTV Survey Sheet 3 of 5

Drawing BW/1812008/4 – Underground CCTV Survey Sheet 4 of 5

6.1.7 The above drawings show that the existing airfield runways onsite drain to gullies which connect to a 650mm diameter sewer which flows in a south easterly direction across the site. The sewer continues offsite, under the Rudford Industrial Estate, and discharges into the River Arun.

6.1.8 It is not proposed to discharge flows from the development into this sewer network as the downstream sewer is not shown on the Southern Water sewer record drawing and is not adopted. The sewer which runs across the site will be removed and capped at site boundary with the Rudford Industrial Estate.

6.1.9 Drawing BW/1812008/3 also shows a 150mm dia sewer which drains the access road within the airfield off Yapton Road. The sewer continues under the Yapton Road and connects to an ordinary watercourse located in a field on the opposite side of the carriageway. The headwall is approximately 38m from the development site boundary. The ordinary watercourse flows in a south westerly direction and eventually discharges into the Ryebank Rife main river. It is proposed to reuse this drainage connection which currently serves the site.

Drawing BW/1812008/5 – Underground CCTV Survey Sheet 5 of 5

6.1.10 A 450mm diameter sewer from the development site crosses the southern boundary and connects into the public surface water sewer in Horsemere Green Lane. The sewer flows westwards and crosses the Yapton Road where it discharges to an ordinary watercourse located within the boundary of Northwood Farm. The headwall is approximately 28m from the development site boundary. The ordinary watercourse is tributary of the Ryebank Rife main river. It is proposed to reuse this drainage connection which currently serves the site.

Drawing BW/1812008/6 – Underground CCTV Survey Sheet 6 of 8

- 6.1.11 This drawing shows an existing 225 mm highway drain which serves the Ford Lane public carriageway in the north west corner of the development site. The drain has no outfall and is considered to be a filter drain in the road side verge.

Drawing BW/1812008/7 – Underground CCTV Survey Sheet 7 of 8

At the centre of the northern boundary of the development there is an existing small pond located adjacent to Ford Lane. The pond has a 150mm diameter sewer outlet which connects into highway drainage and continues northwards under Ford Lane where it discharges into an open ditch. The ditch flows northwards and eventually connects to an ordinary watercourse which is a tributary of the Little Tortington Stream. This flows east and discharges into the River Arun.

Drawing BW/1812008/8 – Underground CCTV Survey Sheet 8 of 8

- 6.1.12 This drawing shows the large deep channel which is located adjacent to the eastern boundary of the development site at the entrance to Ford Airfield off Ford Road. The outlet to the channel is a 1800 x 1200 box culvert which crosses under Ford Road and discharges to an ordinary watercourse which is a tributary of the River Arun located 0.5km to the east.
- 6.1.13 It is proposed to discharge the majority of the Ford Airfield development site to the existing drainage channel. This mimics the existing site whereby surface water discharges to the River Arun which is discussed in more detail in Section 10. Flows will be restricted to Greenfield runoff rate.

6.2 Review of GIS Information Provided by ADC in March 2019

- 6.2.1 Following a pre planning application drainage meeting held on 8 March 2019 ADC provided an electronic copy of Geographic Information System (GIS) data on the site and the surrounding area. It contained information on historic surface water sewer and ordinary watercourse routes.
- 6.2.2 The GIS information has been overlaid onto the site topographical survey and CCTV survey and drainage trace information. Refer to JNP Drawing C85228 SK118 titled GIS Information Review Satellite Image and C85228 SK119 titled GIS Information Review Notes in Appendix B.
- 6.2.3 The drawings show that the private sewer which runs diagonally across the development site only serves the onsite gullies from the runways and that there are no additional upstream connections. Therefore, this sewer can be removed. No sewer diversions are required onsite.
- 6.2.4 There is no evidence of any other culverted watercourses or ditches which run through the site, in addition to those identified and CCTV surveyed by CD Surveys and discussed above.
- 6.2.5 There are private surface water sewers outside the development site boundary which will not be affected by the development and presumably will be retained.
- 6.2.6 The GIS information confirms the location and routes of the ordinary watercourses as discussed in Section 6.1 above.

7 EXISTING FLOOD RISK

7.1 Flood Risk Guidance

- 7.1.1 The Level 1 and Level 2 SFRA Final Report by JBA Consulting (November 2016) commissioned by ADC has been used to obtain flood risk information for the development site and the localised surrounding area.
- 7.1.2 The Level 2 SFRA includes a detailed assessment of the Ford Airfield development site which supports its inclusion as a strategic housing site (Reference SD8) in the Adoption Arun Local Plan 2011- 2031 (July 2018).
- 7.1.3 Further, site specific ground investigation and assessment has been carried out to assess the development site in more detail.

7.2 National Planning Policy

- 7.2.1 The PPG, which supports NPPF, defines three Flood Zones in relation to river flooding. These are defined as:
 -  Flood Zone 1 (Low Probability): This zone comprises land assessed as having less than a 1in1000 annual probability of river flooding;
 -  Flood Zone 2 (Medium Probability): This zone comprises land assessed as having between a 1in100 and 1in1000 annual probability of river flooding; and
 -  Flood Zone 3 (High Probability): This zone comprises land assessed as having greater than a 1in100 annual probability of river flooding.
- 7.2.2 The EA's Fluvial Flood Map for Planning shows a very small area inside the northern boundary of the site, approximately 0.01km² in size, is located in Flood Zone 3 (1.0% or greater annual probability of river flooding or 0.5% or greater annual probability of coastal flooding). No development will be carried out in the Flood Zone 3 area which will be public open space.
- 7.2.3 The residential development is within Flood Zone 1. As a result, the site is considered to be at low risk of fluvial and coastal flooding, as defined above.
- 7.2.4 Copies of all flood risk maps obtained from the EA, discussed below in Sections 7.4 to 7.10, are provided in Appendix O.

7.3 Climate Change

- 7.3.1 In accordance with the PPG, a site-specific flood risk assessment must consider the following question:

"How is flood risk at the site likely to be affected by climate change?"
- 7.3.2 The EA in February 2016 provided guidance on the predicted impacts of climate change on peak river flow and rainfall intensity over the next 100 years. The site is located in the South East Basin District, where peak river flow is predicted to increase by 25-105% by 2115. Peak rainfall intensity is predicted to increase by up to 40% by 2115.
- 7.3.3 Residential development has an expected minimum lifetime of 100 years, so to ensure that the development is safe from the effects of flood risk through this lifetime, climate change must be considered. The below assessment takes account of the forecasted effects of climate change on all possible sources of flood risk (fluvial, tidal and surface water drainage).

7.4 Sequential Test and Exception Test

7.4.1 In accordance with the NPPF:

"The aim of the sequential Test is to steer new developments to areas with the lowest probability of flooding. Development should not be allocated or permitted if there are reasonably available sites appropriate for the proposed development in areas with a lower probability of flooding."

7.4.2 Where areas of lower risk are not available, the Exception Test, as set out in paragraph 102 of the NPPF can be applied, to ensure flood risk management for people and property meets the required level of standard.

7.4.3 The SFRA Level 2 Detailed Site Summary Table for the Ford Airfield development site advises " the Exception Test would not be required for this site as it is entirely located within Flood Zone 1".

7.5 Flood Risk from Rivers (Fluvial)

7.5.1 The land which will be developed is located in Flood Zone 1 and therefore has low risk of flooding from fluvial sources (less than 0.1% annual probability).

7.5.2 A very small area inside the northern boundary of the site, approximately 0.01km² in size, is located in Flood Zone 3 (1.0% or greater annual probability of river flooding). No development will be carried out in the Flood Zone 3 area which will be public open space.

7.5.3 It is noted that two short localized sections of public road, Ford Lane to the north and Ford Road to the east, which are outside the site boundary, are located inside Flood Zone 3. However, the development will include an access and egress route to Yapton Road, west of the site, which avoids the Flood Zone 3 areas.

7.6 Coastal and Tidal Flood Risk

7.6.1 The River Arun is a tidal river. The EA flood map for tidal flooding shows that a small area within the development site is at risk of flooding for the 1 in 200 year (2115), undefended modelled event. With reference to the topographical survey the area is low lying ground.

7.6.2 No residential development is proposed in the area at risk of extreme tidal flooding. However, it is reasonable to locate an attenuation basin in this area and defend the basin from coastal flooding.

7.6.3 The site has a low risk of tidal flooding.

7.7 Groundwater Flood Risk

7.7.1 The 2016 SFRA for ADC shows the site to be <25% susceptible to groundwater flooding.

7.7.2 RSK commenced groundwater monitoring on site in August 2018 to obtain at least 12 months of groundwater levels data.

7.7.3 To date the worst case groundwater levels occurred on 19 December 2019. Groundwater was recorded between 0.80m and 3.90m below ground level. Converting groundwater levels to Above Ordnance Datum (AOD) provides a groundwater range of 4.35m AOD (BH1) in the south of the site to 1.75m AOD (BH5) in the north east.

7.7.4 Although the onsite groundwater monitoring shows raised levels in the southeast of the site, groundwater emergence has not occurred onsite. The hydraulic gradient of the groundwater across the site has a level difference of over 2.5m and flows in an easterly and north easterly direction.

7.7.5 Based on the current site investigation findings the site has a low risk of groundwater flooding.

7.8 Surface Water Flood Risk (Overland Flows)

7.8.1 Surface water flooding occurs when rainwater does not drain away through the normal drainage system or infiltrate into the ground, but instead lies on or flows over the ground.

7.8.2 Surface water flood risk maps have been obtained from the EA. The maps were produced using 'direct rainfall' modelling. Although they take into account local drainage capacity, non-surface water influences such as rivers, sea or groundwater are not considered. The map is based on LiDAR topographic data which is not suitable for site specific assessment and therefore, where available, site specific topographic survey data should be used to provide a more accurate understanding of potential flow paths.

7.8.3 The EA Surface Water Flood Risk Map shows localised areas of surface water flooding across the site at the following locations:

-  Along the western boundary of the site in the vicinity of Ford Industrial Estate. This appears to be flooding from surface water flows generated both off site and onsite;
-  Towards the north west corner of the site, adjacent to the site boundary, where there is an existing industrial unit. This appears to be flooding from surface water flows generated both off site and onsite;
-  Towards the centre of the site where there are localised pockets of low ground. This appears to be flooding from surface water flows generated onsite.
-  Towards the south west of the site adjacent to Yapton Road and the Ford Air Rifle ranges. This appears to be flooding from surface water flows generated onsite.
-  Offsite to the south of Horsemere Green Lane low risk flooding occurs within the existing housing development. This does not appear to be as a result of flows from the development site.
-  In the north east localised high risk flooding is shown in a low lying area onsite. It appears that offsite flows from Ford Lane contribute to the flooding. However, the surface water flood model might not allow for the ordinary watercourse which would receive flows from the road. With reference to the topographical survey the site levels at the highway boundary are on average 1m higher than the road. This would reduce surface water flooding onsite. No development is proposed in the area onsite which is indicated to be at risk of flooding and therefore no properties are at risk as a result of the development.

7.8.4 The above areas are defined as low risk flooding with each year having a chance of flooding between 1 in 100 (1%) and 1 in 1000 (0.1%) unless stated otherwise.

7.8.5 Surface water flooding, particularly in the areas identified above, will be addressed as part of the drainage design for the development. The finished surface levels across the development will be designed so that any escape of water or exceedance flow from the underground drainage system, which will be designed to contain flows for the 1 in 100 year + 40% Climate Change storm event, are diverted away from properties to areas of lesser risk such as green routes and open space.

7.9 Sewer / Drainage Flood Risk

7.9.1 Sewer flooding occurs when excess surface water run-off enters the drainage network and the surface/foul water network is insufficient to deal with the influx of water. Sewer flooding can also occur due to 'one off' events such as blockages in the network.

-
- 7.9.2 The 2016 SFRA for ADC states that there were 20 recorded incidents of sewer related flooding in the same postcode as the site (these records were taken from the DG5 register and therefore only data from 2006 to 2016 is incorporated into the data set shown). The 2016 SFRA for ADC also notes that the majority of sewer related flooding that occurred within the area is related to the foul sewer network.
- 7.9.3 Based on pre planning application discussions, Southern Water has advised the Ford Wastewater Treatment Works, located immediately east of the development site, has capacity for the Ford Airfield development. It is envisaged the proposed foul water drainage system for the new development will connect directly to the wastewater treatment works
- 7.9.4 Southern Water asset location plans for the site show 3 no. rising mains crossing the site and connecting into the wastewater treatment works. The rising mains will be retained and protected if necessary. It is not proposed to divert the existing rising mains and the roads and access routes to serve the new development will be located over the rising mains as shown on the Illustrative Masterplan.
- 7.10 **Reservoir Flood Risk**
- 7.10.1 The EA's Reservoir Flood Map shows no risk to the site.

8 GREENFIELD RUNOFF ASSESSMENT

8.1 Existing Site Surface Water Run-Off

- 8.1.1 The site currently consists mainly of open agricultural fields or woodland/ scrub. Existing impermeable areas onsite comprise former airfield runways, hardstandings and existing buildings.
- 8.1.2 The impermeable areas are drained by onsite surface water sewers which either discharge to the River Arun or to ordinary watercourses which discharge to the Ryebank Rife main river.
- 8.1.3 The site is generally flat with no definitive surface drainage routes, land drains or ditches which collect water. The fields onsite are used for agriculture and surface water which falls on the site is used by evapotranspiration of the vegetation. Some surface water collects locally where there are low-lying areas onsite.
- 8.1.4 Soil infiltration rate testing carried out 2.1m to 2.8m below existing ground level, shows the ground underlying the site, at this depth, ranged between slow marginal infiltration to no infiltration. Shallow infiltration rate testing will be carried out prior to detailed design of the drainage infrastructure to serve the development site. This is discussed in more detail in Section 10 below.

8.2 Existing Greenfield Run-off Rates

- 8.2.1 To inform the design and ensure there is no increase in surface water from the site, the existing run-off rates for a variety of return periods have been calculated per hectare using the HR Wallingford Greenfield Runoff Tool based on the Flood Estimation Handbook (FEH) Statistical Method. The calculations are provided in Appendix C.
- 8.2.2 The calculated Greenfield run off rates are provided below.

Storm Event	Run-Off (l/s/Ha)
QBAR	1.14
1 in 1 year	0.97
1 in 30 year	2.61
1 in 100 year	3.62

Fig 3 Greenfield Runoff Rates for the site

9 PROPOSED DEVELOPMENT ASSESSMENT

- 9.1 The development will comprise up to 1,500 dwellings, employment, local centre comprising retail / commercial and community uses, two-form entry primary school, public open space, allotments, sports pitches, drainage, parking and associated access, infrastructure and landscaping. A copy of the Illustrative Masterplan for the development is provided in Appendix N.
- 9.2 In accordance with Table 2 of the Planning Practice Guidance (PPG) on Flood Risk and Coastal Change the above site uses have the following Flood Risk Vulnerability Classifications.

Site Use	Flood Risk Vulnerability Classification
Building used for dwelling houses	More Vulnerable
Non-residential uses for health services, nurseries and educational establishments	More Vulnerable
Buildings used for shops, offices, general industry and leisure	Less Vulnerable
Amenity open space	Water Compatible Development
Sewage transmission infrastructure and pumping stations	Water Compatible Development

Fig 4 Flood risk vulnerability classification in accordance to Table 2 of PPG Flood Risk and Coastal Change

- 9.3 Appropriate uses of land within classified flood zones can be summarised below in accordance with Table 3 of PPG on Flood Risk and Coastal Change on Flood Risk Vulnerability and Flood Zone Compatibility. The above site uses are appropriate development to be located within Flood Zone 1.

Table 3: Flood risk vulnerability and flood zone 'compatibility'

Flood risk vulnerability classification (see table 2)	Essential infrastructure	Water compatible	Highly vulnerable	More vulnerable	Less vulnerable
Zone 1	✓	✓	✓	✓	✓
Zone 2	✓	✓	Exception Test required	✓	✓
Zone 3a	Exception Test required	✓	×	Exception Test required	✓
Zone 3b functional floodplain	Exception Test required	✓	×	×	×

Key: ✓ Development is appropriate.
 × Development should not be permitted.

Fig 5 Flood risk vulnerability and flood zone compatibility taken from Table 3 of Flood Risk and Coastal Change

10 SURFACE WATER DRAINAGE ASSESSMENT

10.1 Surface Water Drainage Assessment

10.1.1 In accordance with NPPF and the supplementary Flood Risk Assessment Guidance Note 1 by the Environment Agency, for sites greater than 1ha and within Flood Zone 1, particular consideration of drainage shall be made to the following:

- Proposals for surface water management which aims to not increase, and where practicable reduce the rate of runoff from the site
- Provide information regarding the surface water disposal methods already in place and their state of maintenance
- An assessment of the surface water runoff volume likely to be generated from the proposed development
- Allowance in the design for climate change
- Information about potential sources of flooding

10.1.2 Standard assessment criteria for new residential developments require no increase in both surface water peak discharge and runoff volume for the 1:100 year storm events including an allowance for climate change. Surface water drainage networks should also be designed with no flooding of the sewer network for at least the 1:30 year storm event. All flows up to the 1:100 year event including an allowance for climate change shall be contained onsite, to mitigate flood risk impact of developments both on and offsite.

10.1.3 In accordance with NPPF and Building Regulations: Part H, Sustainable Urban Drainage (SUDs) techniques should be the primary method to be considered for the disposal of surface water at source, followed by discharge to a watercourse or finally to a public sewer.

10.2 SuDS Management Train Approach

10.2.1 The SUDs Management Train approach, based on guidance within CIRIA C753 The SUDS Manual, should be adopted to manage and control peak discharge and treating flows to limit the impact on the environment. The management train incorporates a hierarchy of techniques:

- Source control including soakaways, permeable paving, infiltration basins, water butts
- Site control including swales, pervious paving, pervious tanked paving, detention basins, ponds and attenuation systems
- Regional control using wetlands and large retention basins

10.3 Source Control

10.3.1 Infiltration to ground is the primary source control technique to delay, store and potentially improve water quality. These techniques include the use of traditional soakaways, infiltration basins, permeable and tanked pavements, swales and water butts.

10.3.2 Soakaways are the most commonly used type of infiltration device in the UK. They store rapid runoff from a single house or from a development and provide efficient infiltration into the surrounding soil. Typical soakaways include rubble filled pits, precast concrete porous chambers or geocellular tanks.

10.3.3 Permeable pavements not only deal with surface water runoff at source, by slowing the rate of runoff and providing temporary storage but are also widely acknowledged to improve water quality. Parking courts and shared access areas lend themselves well to the use of permeable pavements.

10.3.4 Water butts are the simplest form of non-potable water re-use and can be cheaply accommodated on an individual plot basis. They are small, off-line storage devices that are designed to capture and store roof runoff.

10.4 Site Control

10.4.1 Where infiltration to ground is not feasible a wider SUDs scheme should be considered, taking into account the following suite of source control techniques to manage surface water.

10.4.2 Swales can be integrated into the drainage network to convey surface water flows. Swales when designed appropriately can add amenity value to developments, reduce surface water flows and can also improve water quality by assisting in the capture of contaminants.

10.4.3 Where the layout is constrained for open landscaping to accommodate retention basins or ponds, underground tanks are commonly used to attenuate flows in the form of oversized pipework, box culverts or geocellular tanks. These units are typically laid under the highway network, car parking courts or public open space.

10.4.4 Where the layout allows, retention basins and ponds can be incorporated into the layout to provide the required surface water attenuation volumes. Again, this form of attenuation system will provide amenity value to the development and is effective in removing urban pollutants.

10.5 Regional Control

10.5.1 For large regional scale developments, the use of wetlands and large retention basins provide similar benefits as described above.

10.6 Infiltration to Ground

Deep Soakaway Testing August 2018

10.6.1 A Geo-environmental and Geotechnical Site Assessment Report was prepared by RSK. Report Reference 29228-R01 (00), dated 06 November 2018. The intrusive site testing was carried out in August and September 2018. This included 9 no. soil infiltration rate tests across the site carried out in accordance to BRE Digest 365 Soakaway Design.

10.6.2 The results of the soil infiltration rate tests are shown on JNP Drawing C85228 D104, titled Infiltration Drainage Assessment, which is provided in Appendix D.

10.6.3 5 no. tests located towards the west and the centre of the site failed to achieve infiltration in accordance with BRE 365 and no infiltration rates were provided in the site investigation report. The remaining 4 no. tests located towards the southeast and northeast of the development site returned soil infiltration rates which ranged between 2.29×10^{-6} m/s and 4.76×10^{-6} m/s.

10.6.4 The RSK site investigation report advises “*in general, infiltration characteristics across the site were found to be poor with the lack of permeability within the upper cohesive ground conditions rendering some infiltration rates incalculable. Where infiltration was observed across the test period, infiltration rates ranged 2.29E-06 m/s (S1) to 4.76E-06 m/s (S5) – i.e. upper bound of poor drainage characteristics.*”

Groundwater Monitoring August 2018 to January 2020

- 10.6.5 RSK commenced groundwater monitoring at 8 locations across the development site in August 2018 for a 12 month period to establish changes in groundwater levels. The locations of the monitoring wells are shown on RSK Drawing 29228-(R01-00) Fig 4, titled Exploratory Hole Location Plan in Appendix E.
- 10.6.6 Additional monitoring wells were installed in September 2019 and December 2019, in advance of the winter, to gather more detailed information. The depths of the monitoring wells range between 2.0m and 5.0m below existing ground level. The locations of the original boreholes and the additional monitoring wells are shown on JNP Drawing C85228 D109, titled Supplementary Soakaway Tests Location Plan in Appendix E.
- 10.6.7 The latest groundwater monitoring results are provided in Appendix E.
- 10.6.8 The seasonal variance in groundwater level across the site is significant. Generally, groundwater levels across the site can rise approximately 2m between summer and winter.
- 10.6.9 To date the worst-case groundwater levels occurred on 19 December 2020. Groundwater was recorded between 0.80m (at location BH1) and 3.90m below ground level across the site. Converting groundwater levels to Above Ordnance Datum (AOD) provides a groundwater range of 4.35m AOD (at location BH1) in the southeast of the site to 1.75m AOD (at location BH5) in the northeast.
- 10.6.10 The direction of groundwater flow beneath the site is in an eastern/ north eastern direction towards borehole BH5 and the River Arun. A groundwater contour plan for the worst case recorded event is provided in Appendix G.

Interpretation of Onsite Infiltration Rates and Groundwater Levels

- 10.6.11 Whilst the infiltration rate results in the southeast and northeast of the site might be considered to be technically feasible, it is often found that excessively large soakaways or deep permeable pavements are required to achieve half drain down of the storage volume within 24 hours requirement in British Research Establishment (BRE 365) Design Guidance for Soakaways.
- 10.6.12 Section 25.2.1 of the 2015 CIRIA SuDS Manual C753 provides the following guidance, *"Infiltration viability should be given full consideration where rates of 10⁻⁶ m/s or greater exist (subject to geotechnical and contamination considerations). Where rates are less than that, the soils can still be used for inception delivery, but disposal of significant volumes of runoff may not be cost effective or appropriate, unless there is a large area of land available for this purpose"*.
- 10.6.13 It is common for approving authorities to deem that infiltration rates of 10⁻⁶ m/s or greater are marginal and surface water should not be discharged into the ground, particularly where ditches or watercourses are present within close vicinity to the development site.
- 10.6.14 Section 4.3.2 of the 2015 CIRIA SuDS Manual C753 recommends that a minimum depth of 1m unsaturated aquifer should be provided between the base of an infiltration system and the maximum groundwater likely groundwater level.
- 10.6.15 We are aware that ADC has previously agreed planning permission for other developments where infiltration drainage with discharge rates of 10⁻⁶ m/s exist and do not require 1m clearance between the base of infiltration SuDS components and maximum likely groundwater level. ADC recognise that shallow infiltration components can be used with groundwater levels 1m below existing ground level. (source planning ref Y/91/17/OUT Land West of Blisham Road, Yapton).
- 10.6.16 Groundwater monitoring carried out on 19 December 2019 recorded groundwater 0.80m below the ground surface at BH1 which is located in the southeast of the site. Although, the soil soakaway rate test

carried out at WS1/ BH1 achieved infiltration other soakaway tests carried towards the south of the site at locations, S2, S3 and S4 all failed to infiltrate. Therefore, deep infiltration techniques such as soakaways are not suitable for the south of the development site.

- 10.6.17 Soil infiltration rate testing in the northwest of the site, at locations S7 and S8, also failed to achieve infiltration and therefore are not suitable for deep infiltration techniques.
- 10.6.18 Soil infiltration rate testing in the northeast of the site showed infiltration rates ranged between 2.29×10^{-6} m/s and 4.76×10^{-6} m/s and groundwater levels are lower in this part of the site. Infiltration / partial infiltration might be possible in some areas.
- 10.6.19 Having assessed maximum anticipated winter groundwater levels across the site, additional soakaway tests will be carried out in February 2020. An additional 47 no. soakaway tests, at depths ranging between 0.50m to 1.50m deep below existing ground level, will be carried out to assess using shallow infiltration techniques.

Infiltration Drainage Discussions with ADC March 2019

- 10.6.20 Based on the findings of the site investigation and concerns regarding slow infiltration rates and high groundwater it is considered that the development cannot be solely served using infiltration drainage. JNP prepared an initial drainage strategy which provided a positive drainage system and attenuation basins to discharge surface water to the River Arun and the Ryebank Rife main river.
- 10.6.21 Due to the flat topography of site the drainage strategy requires surface water to be pumped offsite. This is explained in more detail in Section 10.7.
- 10.6.22 The proposed positive drainage system will serve most of the site where the deep infiltration rate testing shows infiltration will not work. However, it allows deep infiltration to be provided onsite where infiltration rates are marginal or where shallow infiltration is feasible as overflows from soakaways or permeable paving could be connected into the positive drainage system to prevent flooding onsite during severe and or repeated storm events. This is explained in more detail in Section 11.
- 10.6.23 The initial drainage strategy was issued to the ADC Drainage and Coastal Department on 5 March 2019 and discussed at a drainage pre planning application meeting held on 8 March 2019.
- 10.6.24 Comments on the site investigation and drainage strategy raised by ADC are provided in the email dated 8 March 2019 provided in Appendix F. The comments that were raised regarding infiltration rate testing are discussed in more detail in the table below.

Fig 6 Pre Planning Application discussion with ADC, 8 March 2019

ADC Comment No.	ADC Comment	JNP Response
1	Infiltration rate testing was completed in August and at considerable depths. Infiltration testing must be completed between October and March. It may be possible for the applicant to complete this before end of March. However, any later that this and they will have to wait until next year. The outline planning process could progress in the meantime as long as a suitable drainage strategy is	The deep infiltration testing carried out in August showed that the ground failed to infiltrate in all areas except in the north east of the site where infiltration rates were marginal. Testing between October and March would not provide more favourable results. As a result, deep infiltration is not a feasible solution for this development.

	included which clearly documents your intentions to follow the hierarch of sustainable drainage. If this step was taken, we would like as much flexibility regarding attenuation locations etc. to be retained should infiltration potential not be established before determination of outline planning.	Additional shallow infiltration rate testing is discussed under ADC Comment No.2 below. Site constraints which impact upon suitable locations for attenuation basins are discussed in Section 10.7.
2	Infiltration testing should be completed above maximum recorded winter groundwater levels and at depths of proposed infiltrating structures. Therefore, I would like to see some shallow infiltration testing at circa 0.5mbgl or appropriate depths for permeable paving. And at potential depths for soakaways, circa 1m. I do not think that soakaways will be sited to depths of over 2m given the geological conditions.	Shallow infiltration rate testing will be carried out to either prove or disprove if this is feasible and determine where onsite shallow infiltration components, such as permeable paving, can be used.
3	Infiltration testing and groundwater monitoring locations are not appropriate to date. Both must be completed at the proposed locations for surface water drainage, yet there is a significant lack of these investigations in the proposed locations of ponds.	Sufficient ground investigation, infiltration rate testing and groundwater monitoring has been carried out to understand the site constraints and determine a feasible sustainable drainage solution for outline planning. As a result of slow and marginal infiltration rates recorded to date it is considered the use of shallow infiltration SuDS components alone will be too large and deep to provide adequate storage for the 100 year + 40% CC storm event and achieve half drain down in 24 hours in readiness for repeated storm events. It is envisaged shallow infiltration components can be used in conjunction with a positive drainage solution which requires attenuation basins onsite. The winter groundwater monitoring carried out to date enables us to assess where the attenuation basins can and cannot be located onsite as discussed in Section 10.7. The basins have been provided in the lowest parts of the site where winter ground levels suggest water ingress will not occur. Locating the ponds in the lowest ground also reduces the requirement to raise ground levels onsite. It is proposed to carry out further shallow infiltration rate testing and groundwater monitoring to refine the drainage proposals during detail design. However, the drainage strategy provided for outline planning is feasible and fully addresses the site constraints.
4	The locations of monitoring and testing are also very sparse, we would expect far more monitoring and testing to be completed for a site of this size. We would anticipate one shallow infiltration test and one deep infiltration test per small housing parcel. We	Following meeting it was proposed to carry out additional shallow infiltration rate testing across the site.

	would also expect a ground water monitoring location within each small parcel.	ADC advised that this should be carried out between October to March and more testing locations should be provided. In order to further inform the drainage strategy tests at the 26 no. locations will be carried out in February 2020 at varying depths ranging from 0.5m to 1.5m deep. Some deeper tests will also be carried out. A total of 47 no. individual soakaway tests will be carried out. The findings of the additional testing do not impact on the proposed design strategy. It is considered the shallow infiltration rates will be slow to prevent standalone infiltration components to be provided for the 100 year + 40%CC event and attenuation basins and pumping stations will be required regardless.
5	I would expect infiltration to be utilised where infiltration rates are found to be greater than $\times 10^{-6} \text{ms}^{-1}$. If half drain times exceed 24 hours for the 1 in 10 year plus climate change event we would permit high level overflows to be utilised which permit the discharge of water to watercourse at QBAR.	Where infiltration rates are slow and marginal the overflows from the infiltration drainage system will need to drain into a positive drainage system. This requires the attenuation basins and pumping stations to be provided.
6	Pumping stations will not be accepted. The fact that these are proposed to me is a demonstration that master planning has not considered surface water drainage properly and that solutions beyond a pipe network have not been considered properly and that attenuation features have been shoe horned into inappropriate areas.	The drainage strategy has considered using just shallow infiltration and this will not be feasible for the large flat site. This is discussed in more detail in paragraph 10.6.25 below. Master planning has been fully considered as evidenced by Section 10.7 and the attenuation basins are located in the most suitable locations. Section 10.7 also explains why it will be necessary to serve the site using surface water pumping stations. In summary, pumping stations are required because the site is large and flat. Installation of gravity sewers over long distances, even at minimal gradients, requires pipelines which are deeper than the existing invert or bed levels of the sewers and outfalls which currently serve the site. Alternatively, raising ground levels onsite to provide gravity sewers is not feasible due to the significant additional height in ground level and volume of fill required.

10.6.25 The site investigation carried out to date provides information to assess and understand drainage options for the development. Shallow infiltration can be used in areas of the site, subject to confirmation of the infiltration rate following shallow tests, however it will not be suitable as the sole method to drain the entire development to the ground, based on the following reasons.

- Based the soil descriptions in the site investigation report it is unlikely that soils at shallow depth across the site will provide significantly higher/ quicker infiltration rates. It is expected that the shallow infiltration rates tests will be in the region of 10^{-6} m/s.
- If designing shallow infiltration drainage, on a parcel by parcel basis, using permeable paving with an infiltration rate of 10^{-6} m/s might require the depth of the permeable sub base to be greater than 1000mm deep if designing to contain surface water runoff for a 1 in 100 year + 40%CC storm event. Even with deep permeable paving in some cases half drain down of storage volume in 24 hours cannot be achieved for the 100 year + 40% CC storm event. This is based previous design experience for a residential development with reasonably sized impermeable catchment areas and marginal infiltration rates.
- ADC recognise this and advise above that "if half drain times exceed 24 hours for the 1 in 10 year plus climate change event we would permit high level overflows to be utilised which permit the discharge of water to watercourse at QBAR". Therefore, a positive drainage system in addition to providing shallow infiltration permeable paving is required.
- The site is a large very flat area. If it was attempted to drain the site to localised shallow permeable paving, site levels would remain flat and it would be impractical to deal with exceedance flows by discharging water overland to green spaces and to areas of lesser vulnerability. Introducing a positive drainage system allows the topography of the flat areas to be raised and sloped to enable exceedance flows to discharge to suitable areas.
- The main onsite access roads which will serve the development will be offered for adoption. WSCC does not adopt permeable paving and deep soakaways are not feasible. The access road could be served using shallow highways infiltration basins but due to the flat topography numerous basins at frequent spacing would be required. The basins would be maintained by the Highways authority. Alternatively, the positive drainage system would be adopted by Southern Water and the receive flows from the highway gullies.

10.7 Connection to Watercourse

- 10.7.1 The above infiltration assessment shows that the development will require surface water to flow to attenuation basins onsite before discharging to watercourse at a discharge rate which is restricted to QBAR.
- 10.7.2 To inform master planning of the proposed development site layout an options appraisal has been carried out to assess the optimum locations of the attenuation basins and the proposed outfalls to watercourse.
- 10.7.3 The outfalls which serve the site have been thoroughly investigated by reviewing GIS information and carrying out CCTV and drainage tracing onsite, as discussed in Section 6.
- 10.7.4 Attenuation basin locations are first considered based on existing site topography. Locating the basin in the lower lying ground onsite enables sewers to be laid following the natural fall and reduces the likelihood or extent of raising ground levels to provide sufficient cover over the sewers.
- 10.7.5 The maximum depth of groundwater at the basin location has been interpolated to ensure that the base of the basin is above the maximum recorded level. This reduces the risk of groundwater ingress into the basin which would occupy attenuation volume.
- 10.7.6 A groundwater contour plan based on the worst cast groundwater monitoring is provided in Appendix G.

The Northern Basin

- 10.7.7 The northern development parcels will discharge surface water to an attenuation basin. With reference Drawing Number C85228 SK121, titled Drainage Solution Options Northern Parcels provided in Appendix H, the basin is located in the lowest area in the northern half of the site.

- 10.7.8 The following options for outfalls to ordinary watercourses to the River Arun have been considered.
- 10.7.9 If the attenuation basin discharges to the open ditch to the east of the site by a gravity sewer the base of the basin would be approximately 4.58m AOD. The incoming sewers to the attenuation basin from the development site would require ground levels to be raised by approximately 1.5m on average across the entire northern half of the site. This is not feasible.
- 10.7.10 If the attenuation basin discharges by gravity to the ordinary watercourse to the north of the development site, which is shallow, the level of the existing Ford Lane public highway would need to be raised by approximately 1.0m to achieve reasonable cover over the gravity sewer where it crosses the carriageway. This is clearly impractical..
- 10.7.11 The preferred outfall option is to provide a pumping station and rising main and discharge water to the open ditch to the east of the site. This enables the base of the attenuation basin to be formed at 2.40m AOD, the maximum anticipated groundwater level and ground levels across the northern parcels to rise and fall in ground level by approximately 600mm above existing ground levels over most of the north of the site. The impact on ground levels is minimal.

The Southern Basin

- 10.7.12 Two options for the location of the attenuation basin and outfall to watercourses have been considered as shown on Drawing Number C85228 SK120, titled Drainage Solution Options Southern Parcels provided in Appendix H.
- 10.7.13 If the basin is located in the lowest lying ground in the south of the site groundwater ingress into the basin would occur. Raising the base level of the basin higher than the maximum interpolated groundwater level (4.7m AOD) results in raising ground levels onsite by generally 1.5m or higher to provide an incoming gravity sewer network to the basin. This is impractical .
- 10.7.14 The alternative location for the basin is the south east corner of the development site where ground water levels are lower (maximum interpolated groundwater level m AOD). The basin could connect, by gravity sewer, to the existing private surface water sewer which crosses the site and continues under the Rudford Industrial estate. However, this is a private sewer and the new onsite sewerage infrastructure, which connects into it, might not be adopted by Southern Water. In addition, this option would result in ground levels being raised by approximately 1.0 to 2.0 m across the southern parcels. Therefore, it is unlikely this option is viable.
- 10.7.15 The preferred option is to locate the basin in the same location as discussed in paragraph 10.7.14 above but to provide a pumping station and rising main and discharge water to the open ditch to the east of the site. The base of the attenuation basin will be 4.40m AOD, maximum interpolated groundwater level, and ground levels across the southern parcels will be raised approximately 0.5 to 1.5m across the southern parcels.

The Northwest Basin

- 10.7.16 The Northwest basin is shown on JNP Group Drawing Number C85228 D101, titled Indicative Surface Water Drainage Strategy Sheet 2 of 2, provided in Appendix H. It receives flows from central area of the site where the parcels are the furthest distance from the outfalls. The basin removes the requirement to significantly raise ground levels, which would be required if the parcels discharged to either the Northern and Southern basins by gravity sewers.
- 10.7.17 The basin is served by a pumping station and rising main which discharges surface water to the Northern basin at 5.0 l/s. The Northern basin has been sized to receive a base flow of 5.0 l/s from the Northwest basin for the 1 in 100 year +40%CC storm event. The discharge rate from Northern basin is restricted to Greenfield runoff based on the catchment area for the parcels which are served by the Northwest basin and the Northern basin.

The Southwest Basins

- 10.7.18 Part of the existing site is served by a 150mm dia existing sewer which is laid under Yapton Road and discharges into an ordinary watercourse which is a tributary of the Ryebank Rife.
- 10.7.19 The topographical survey shows that part of the site falls towards the southwest boundary. This area will be served using a gravity sewer to this outfall. This mimics the existing situation onsite. The flow will be restricted to Greenfield runoff rate and attenuation basins will be required. The basins are shown as Basin 2a and Basin 2b on JNP Group Drawing Number C85228 D101, titled Indicative Surface Water Drainage Strategy Sheet 2 of 2, provided in Appendix I.
- 10.7.20 A groundwater monitoring well (BH2) is located close the southwest boundary of the site where the attenuation basins will be located. The maximum recorded groundwater level over the winter monitoring period was 5.396m AOD. The base of the basins will be 5.45m AOD.
- 10.7.21 The ground levels within that basin catchment area will need to be raised approximately 0.30 to 1.50m higher than existing ground level to discharge to the basins by gravity sewer. Alternatively, the ground would need to be raised higher if connected to the Southern basin by gravity sewer which would need to extend a considerable distance across the site.

The Southeast Tank

- 10.7.22 Historically, part of the development site discharged to a 450mm dia existing sewer which is laid in Horsemere Green Lane and crosses under Yapton Road to discharge into an ordinary watercourse which is a tributary of the Ryebank Rife.
- 10.7.23 The outfall will be used to discharge an area of the existing ground onsite which falls in this direction. The groundwater was recorded 0.80m below the existing ground level in this area (BH1) which is 4.35m AOD.
- 10.7.24 It is proposed to attenuate water using tank sewers and an underground tank to serve this part of the site. The tank is shown as Tank 3 on JNP Group Drawing Number C85228 D101, titled Indicative Surface Water Drainage Strategy Sheet 2 of 2, provided in Appendix I. The flow will be restricted to Greenfield runoff rate
- 10.7.25 The ground levels within the basin catchment area will need to be raised approximately 0.60 to 1.80m higher than existing ground level to discharge to the outfall by gravity sewer. Alternatively, the ground would need to be raised higher if connected to the Southern basin by gravity sewer which would be laid a considerable distance across the site.
- 10.7.26 More detailed information on the proposed drainage strategy is provided in Section 11.

Greenfield Runoff Catchment Analysis

- 10.7.27 The existing flat topography of the site is shown by the existing ground levels and contours on JNP Drawings C85228 SK120 titled Drainage Solution Options Southern Parcels and C85228 SK121 titled Drainage Solution Options Northern Parcels in Appendix H.
- 10.7.28 The drawings also indicate localised shallow low lying areas onsite where surface water runoff might be expected to collect during a severe storm or repeated storms. There are no defined ditches or land drains onsite which capture surface water.
- 10.7.29 The north of the site generally falls west to east in the direction of the ordinary watercourse to the north of the site off Ford Lane and the open ditch in the east adjacent to Ford Road. Both watercourses discharge to the River Arun.
- 10.7.30 The south of the site generally falls to the southwest. The majority of surface water would be intercepted by the positive drainage systems which serve runway and roads onsite. The private surface water sewers
-

which cross the site might also capture water within granular bedding and backfill material which surround the pipe. The onsite sewers discharges water to the River Arun.

- 10.7.31 A relatively small section of the total site area falls to the south west boundary. There are 2 no. positive drainage systems in the vicinity of this area which discharge to ordinary watercourses which are tributaries of the Ryebank Rife as discussed above.
- 10.7.32 It is proposed to utilise the existing connection routes from the development site to the ordinary watercourses which discharge to the River Arun and the Ryebank Rife.
- 10.7.33 Based on information above it is reasonable to apply the QBAR Greenfield runoff rate calculated in Section 8 to the catchment areas in the north and south of the site and discharge the flow via the existing deep channel to the east of the site, adjacent to Ford Road, to the River Arun.
- 10.7.34 The areas of the existing site which fall towards the south west boundary are representative of the catchment areas of the Southwest Basin and Southwest Tank. This ground falls in the direction of ordinary watercourses which are tributaries of the Ryebank Rife main river. Existing sewers which serve the southwest of the site discharge water to the watercourses.
- 10.7.35 QBAR Greenfield runoff rates from the attenuation components are provided in Section 11.0 below.

11 PROPOSED SURFACE WATER DRAINAGE STRATEGY

11.1 Surface Water Drainage Strategy

- 11.1.1 The soil infiltration rate tests carried out onsite and discussed in Section 10.6 above suggest that deep partial infiltration / infiltration might only be feasible in the northeast of the development site.
- 11.1.2 Section 6 shows that the existing infrastructure on the Ford Airfield site is not served by infiltration. The site is served by numerous surface water drainage connections either to ditches or short lengths of sewers which discharge to watercourses. The watercourse eventually flow to the River Arun or the Ryebank Rife main river.
- 11.1.3 The primary drainage solution for the development is to provide onsite attenuation basins/wetlands and discharge surface water at Greenfield runoff rate to the existing watercourses which serve the site. The new development will restrict the flow of water to the existing outfalls and therefore provide a reduction and betterment in flow from the site into the downstream drainage systems and watercourse.
- 11.1.4 The attenuation basins will be sized to receive surface water runoff from all impermeable areas and hardstanding across the site. This is currently based on the worst case with no water infiltrating into the ground. The proposed surface water sewer networks and basins are shown on JNP Drawing Nos. C85228 D100 and C85228 D101 titled indicative Surface Water Drainage Strategy, provided in Appendix I.
- 11.1.5 If the use of shallow infiltration drainage components proves feasible and appropriate, then some water from the site would recharge groundwater supplies and reduce the load on the positive drainage system during severe storm events. It is envisaged that permeable paving might be used for private driveways and private shared roads where feasible.
- 11.1.6 As the development site is a former Airfield it is generally flat and level. It will be necessary to raise ground levels in parts of the site to provide gravity sewers to discharge water to the basins. Generally, the ground will be raised higher where it is furthest from the basin.
- 11.1.7 Where the depth of the existing site drainage outfall(s) is shallow it will be necessary to pump surface water from the attenuation basin to the outfall. Where possible gravity sewers to the site outfalls will be used, however, this is limited by raising ground levels across the to facilitate this.
- 11.1.8 The attenuation basins have been located in the lower regions of the site, subject to the worst case groundwater levels onsite, to make use of the existing slight natural gradient across the site and to ensure they are close to the existing site outfalls.
- 11.1.9 With reference to JNP drawings titled indicative Surface Water Drainage Strategy, Drawing Numbers C85228 D100 and C85228 D101, provided in Appendix I the following attenuation basins / tanks and outfalls are proposed. Refer to Figure 7 below.

Site Catchment Area	Attenuation	Discharge System	Greenfield Runoff Rate QBAR	Outfall
North	Northern Basin	Pumping station and rising main at Greenfield runoff rate	23.5 l/s (Northern 21.5 l/s + Northwest 2.1 l/s)	Pumped flow discharging to the large channel to the east of the site adjacent to Ford Road. Channel discharges to the River Arun.
Northwest	Northwest Basin	Pumping station and rising main	Pumping rate of 5 l/s applied (to transfer flow to other basin)	Pumped flow discharges into the onsite gravity sewer which flows into the Northern Basin.
South	Southern Basin	Pumping station and rising main at Greenfield runoff rate	14.9 l/s	Pumped flow discharging to the large channel to the east of the site adjacent to Ford Road. Channel discharges to the River Arun.
Southwest	Basin 2A and Basin 2B	Gravity sewer with discharge rate restricted to Greenfield runoff rate A minimum discharge rate of 2 l/s has been applied in accordance to ADC requirements.	1.6 l/s Min discharge rate of 2 l/s applied	Gravity sewer connection to the existing 150mm dia surface water sewer which carries existing flows under Yapton Road to a watercourse which is a tributary of the Ryebank Rife. Note the sewer is approximately 38m long between the site and the watercourse.
Southeast	Underground Tank 3 and tank sewers	Gravity sewer with discharge rate restricted to Greenfield runoff rate A minimum discharge rate of 2 l/s has been applied in accordance to ADC requirements.	1.3 l/s Min discharge rate of 2 l/s applied	It is proposed to abandon the 450mm dia sewer which currently serves this part of the site and bypass the existing public sewer in Horsemere Green Lane. Gravity sewer connection to the existing 450mm dia surface water sewer which carries existing flows the under Yapton Road to a watercourse which is a tributary of the Ryebank Rife. Note the sewer is approximately 28m long between the site and the watercourse.

Fig 7 – Summary of Surface Water Drainage Systems for the Proposed Development

- 11.1.10 Existing Greenfield Runoff Rates have been calculated using the FEH rainfall model. The calculated greenfield runoff rates are provided in Appendix C.
- 11.1.11 All post development runoff from the site will be limited to existing Greenfield runoff rate (QBAR) during all storm events up to and including the 1 in 100 year + 40% Climate Change event.
- 11.1.12 The total Greenfield runoff rate from the development which discharges to the channel to the east of the development which is a tributary of the River Arun is 38.4 l/s (combined flow from North, Northwest and South catchment areas). The flows to the 2 no. tributaries of the Ryebank Rife will each be restricted to 2.0 l/s.
- 11.1.13 However, the post development flows from the site replace existing unrestricted sewers and provide significant betterment by reducing the flow to the downstream water environment.
- 11.1.14 The surface water drainage strategy, shown on drawings C85228 D100 and C85228 D101, has been prepared based on semi detailed Micro Drainage sewer network drainage calculations to confirm

feasibility. The sewer network has been designed to ensure that no surface water flooding occurs onsite for the 1 in 100 + 40% Climate Change storm event.

- 11.1.15 The calculations also confirm attenuation basin sizes, cover levels and finished ground levels across the development site. The calculations are provided in Appendix J.

11.2 Flood Exceedance Routing

- 11.2.1 The EA surface water flood map identifies small areas of localised surface water flooding onsite where runoff ponds in low lying ground. The areas are defined as low risk flooding with each year having a chance of flooding between 1 in 100 (1%) and 1 in 1000 (0.1%).
- 11.2.2 The finished ground levels for the development will be designed to remove existing low lying areas or provide drainage in low lying areas. Any water which flows towards the development from offsite areas will be intercepted by green routes.
- 11.2.3 Therefore, flooding and overland flow routes will only become operational for exceedance flows which are greater than the 1 in 100 year + 40% Climate Change storm event or if the sewerage system suffers an escape of water due a collapse or blockage.
- 11.2.4 The finished ground levels for the development will be designed so that water will flow from the properties towards the channelized road network. The road network has been designed to channel overland flows towards areas of lower risk, comprising green corridors, open space and the drainage basins.
- 11.2.5 The public highway road levels have been designed to rise and fall across the site to direct surface water runoff into gullies. However, during an extreme flood exceedance event surface water will overtop the crowns in the carriageway and flow to green spaces. This is shown on JNP Drawing No. C85228 D102 and D103 titled Indicative Flood Exceedance Plan in Appendix K.

11.3 Ground Level Raising Onsite

- 11.3.1 The difference in ground levels between the existing ground and proposed finished levels are provided in JNP Drawings C85228 D110 and C85228 D111, titled Indicative Proposed Ground Levels, provided in Appendix L.
- 11.3.2 In the north of the site ground levels increase is not significant. Over the majority of the north of the site the finished ground level will rise and fall by approximately 0.60m. It increases up to 1.0m above existing ground level in localised areas.
- 11.3.3 In the south of the site it is envisaged ground levels in the vicinity of the Southern Basin will be raised on average no greater than 0.50m. The requirement to raise ground levels higher increases moving further west away from the southern basin.
- 11.3.4 The maximum rise in ground level occurs along a ridge which runs parallel to the south west boundary of the site as indicated on drawing C85228 D111. The rise in ground level along the ridge generally varies between 1.00m to 1.5m above existing ground level. In one small localised area the ground level will be 2.0m above existing ground level. The finished ground levels then fall in a south westerly direction to tie into existing ground levels along the boundary of the site adjacent to Yapton Road.
- 11.3.5 It is necessary to raise the ground level across the site for the following reasons:
-  The findings of the site investigation report shows that infiltration drainage and soakaways are not suitable. If shallow infiltration drainage can be provided onsite it is envisaged that it will require overflows to a positive drainage system.

- As in accordance with the SuDS hierarchy the development will discharge surface water runoff to nearby watercourses. Therefore, a sewer network and attenuation basins are required onsite.
- The base of the attenuation basins must be located above the highest anticipated groundwater level. The basins have been located in the lowest parts of the site where this can be achieved.
- The site is a former airfield therefore is generally flat. Raising the ground onsite is required to provide gravity sewers onsite which fall and discharge into the attenuation basins. A sufficient depth of backfill material needs to be provided over the sewers for pipe protection and to enable connections from incoming private sewers.
- The finished ground levels across the site have been designed to ensure that any exceedance flows / overland water flows away from the buildings towards the roads and eventually towards greenspace areas of lesser risk.

11.3.6 Preliminary earthworks assessment indicates that fill material to raise the ground onsite will be sourced mainly from construction earthworks arisings subject to geotechnical testing for compliance.

11.4 Sustainable Drainage Systems (SuDS)

11.4.1 As part of the drainage design SuDS will be provided to manage and control peak discharge and treat flows to improve water quality to limit the impact to the water environment. It is envisaged the following SuDS components will be provided.

Infiltration Permeable Paving

Shallow infiltration rate testing will be carried out to confirm where infiltration permeable paving can be provided. It is envisaged due to the slow infiltration rates that overflows from the permeable paving will be required and connect into the onsite positive drainage system.

Infiltration Soakaways

11.4.2 Shallow soakaways will be used where feasible. Again, the soakaways would be provided with overflows to the positive drainage system.

Tanked Permeable Paving

11.4.3 In areas of the site where shallow soakaway testing shows infiltration drainage is not feasible tanked permeable paving will be provided. Private drives are particularly suitable for this technique as it improves water quality. Roof drainage can be connected to the tanked permeable paving.

Attenuation Basins

11.4.4 After passing through the upstream SuDS system water will flow to the attenuation basins. The basins are mainly dry depressions in the ground designed to hold water for retention. During low flows water will flow over the grass surface enroute to the outfall which provides good contaminant attenuation potential.

11.4.5 Within the attenuation basins pockets of water will be provided to create small ponds which will provide amenity and biodiversity value.

12 WATER QUALITY

12.1 Water Quality

- 12.1.1 Managing pollution close to the source can help keep pollutant levels and accumulation rates low, essentially allowing natural treatment processes to be effective. This in turn can help maximise the amenity and biodiversity value of downstream surface SuDS components and keep maintenance activities straightforward and cost-effective.
- 12.1.2 The proposed development land use is mainly residential comprising; residential roofs and individual property driveways / residential car parks / low traffic roads. These land uses are classified as having very low and low hazard pollution levels, respectively. As per Table 4.3 of the 2015 SuDS Manual (C753), the minimum water quality management requirement for discharges to surface water requires the Simplified Index Approach to be applied, which has replaced the previous requirement to provide 'treatment stages'. The Simplified Index Approach uses the following steps:
- 12.1.3 **Step 1:** Allocate suitable pollution hazard indices for the proposed land use
- 12.1.4 **Step 2:** Select SuDS with a total pollution mitigation index that equals or exceeds the pollution hazard index
- 12.1.5 **Step 3:** Where the discharge is to protected groundwater, consider the need for a more precautionary approach.
- 12.1.6 **Step 1:** Table 26.2 of the 2015 SuDS Manual (C753) sets out the required pollution hazard indices for various land uses. The pollution hazard indices for the total suspended solids (hereon referred to as TSS), metals and hydro-carbons is 0.2, 0.2 and 0.05, respectively, for residential roofs and 0.5, 0.4 and 0.4, respectively, for property driveways / residential car parks / low traffic roads. This table is provided below in Figure 8.

Land use	Pollution hazard level	Total suspended solids (TSS)	Metals	Hydrocarbons
Residential roofs	Very low	0.2	0.2	0.05
Other roofs (typically commercial/industrial roofs)	Low	0.3	0.2 (up to 0.5 where there is potential for metals to leach from the roof)	0.05
Individual property driveways, residential car parks, low traffic roads (eg cul de sacs, homezones and general access roads) and non-residential car parking with infrequent change (eg schools, offices) ie < 300 traffic movements/day	Low	0.5	0.4	0.4
Commercial yard and delivery areas, non-residential car parking with frequent change (eg hospitals, retail), all roads except low traffic roads and trunk roads/motorways*	Medium	0.7	0.6	0.7
Sites with heavy pollution (eg haulage yards, lorry parks, highly frequented lorry approaches to industrial estates, waste sites), sites where chemicals and fuels (other than domestic fuel oil) are to be delivered, handled, stored, used or manufactured, industrial sites, trunk roads and motorways*	High	0.8†	0.8†	0.8†

Fig 8 – Summary of Surface Water Drainage Systems for the Proposed Development

12.1.7 As highlighted below, Table 4.3 in the SuDS Manual (C753) advises that for residential roofs the pollution hazard level is very low and the minimum requirement to discharge to surface water is for the removal of gross solids and sediments only. This is shown in Figure 9 below.

TABLE 4.3 Minimum water quality management requirements for discharges to receiving surface waters and groundwater			
Land use	Pollution hazard level	Requirements for discharge to surface waters, including coasts and estuaries ¹	Requirements for discharge to groundwater
Residential roofs	Very low	Removal of gross solids and sediments only	
Individual property driveways, roofs (excluding residential), residential car parks, low traffic roads (eg cul de sacs, home zones, general access roads), non-residential car parking with infrequent change (eg schools, offices)	Low	Simple index approach ² Note: extra measures may be required for discharges to protected resources ³	
Commercial yard and delivery areas, non-residential car parking with frequent change (eg hospitals, retail), all roads except low traffic roads and trunk roads/motorways	Medium	Simple index approach ² Note: extra measures may be required for discharges to protected resources ³	Simple index approach ² Note: extra measures may be required for discharges to protected resources ³ In England and Wales, Risk Screening ⁴ must be undertaken first to determine whether consultation with the environmental regulator is required. In Northern Ireland, the need for risk screening should be agreed with the environmental regulator.
Trunk roads and motorways	High	Follow the guidance and risk assessment process set out in HA (2006)	
Sites with heavy pollution (eg haulage yards, lorry parks, highly frequented lorry approaches to industrial estates, waste sites), sites where chemicals and fuels (other than domestic fuel oil) are to be delivered, handled, stored, used or manufactured, industrial sites	High	Discharges may require an environmental licence or permit ⁵ . Obtain pre-permitting advice from the environmental regulator. Risk assessment is likely to be required ⁶ .	

Fig 9 Minimum water quality management requirements for discharges to receiving waters and groundwaters
2015 SuDS Manual (C753)

12.1.8 **Step 2:** The detailed drainage design utilises the following SuDS features to address water quality:

- Permeable pavements to capture surface water runoff at source for access roads and all car parking areas.
- Detention / attenuation basins are provided to attenuate and discharge surface water runoff from the adoptable roads.

12.1.9 The indicative SuDS mitigation indices for discharges to surface waters are provided in Table 26.3 of the 2015 SuDS Manual (C753) for the proposed SuDS components. This table is provided below.

TABLE 26.3 Indicative SuDS mitigation indices for discharges to surface waters				
Type of SuDS component	Mitigation indices ^a			
	TSS	Metals	Hydrocarbons	
Filter strip	0.4	0.4	0.5	
Filter drain	0.4 ^b	0.4	0.4	
Swale	0.5	0.6	0.6	
Biosatiation system	0.8	0.8	0.8	
Permeable pavement	0.7	0.6	0.7	
Detention basin	0.5	0.5	0.6	
Pond ^c	0.7 ^b	0.7	0.5	
Wetland	0.8 ^b	0.8	0.8	
Proprietary treatment systems ^{a,c}	These must demonstrate that they can address each of the contaminant types to acceptable levels for frequent events up to approximately the 1 in 1 year return period event, for inflow concentrations relevant to the contributing drainage area.			

Fig 10 . Indicative SuDS Mitigation Indices for Discharges to Surface Waters 2015 SuDS Manual (C753)

- 12.1.10 To deliver adequate treatment, the selected SuDS components should have a total pollution mitigation index (for each contaminant type) that equals or exceeds the pollution hazard index (for each contaminant type), as follows:

Total SuDS mitigation index $\geq$ pollution hazard index

(for each contaminant type) (for each contaminant type)

- 12.1.11 For each type of land-use, the pollution hazard indices, mitigation indices and concluding hazard have been outlined in Figures 11 and 12 below.

Property driveways/residential car parks/low traffic roads				SuDS Manual Reference
	TSS	Metals	Hydrocarbons	
Pollution Hazard Index	0.5	0.4	0.4	Table 26.2
Mitigation Index Permeable Pavement	0.7	0.6	0.7	Table 26.3
Result	Total SuDS mitigation index $\geq$ pollution hazard index and therefore hazard is exceeded			

Fig.11 Permeable Paved Roads / Car park Water Quality Mitigation Summary

Property driveways/residential car parks/low traffic roads				SuDS Manual Reference
	TSS	Metals	Hydrocarbons	
Pollution Hazard Index	0.5	0.4	0.4	Table 26.2
Mitigation Index	0.6	0.5	0.6	Table 26.3
Swale / Detention Basin				
Result	Total SuDS mitigation index $\geq$ pollution hazard index and therefore hazard is exceeded			

Fig.12 Detention Basin Water Quality Mitigation Summary

- 12.1.12 Therefore, the provision of permeable paving and detention basins exceeds the required pollution mitigation indices and provides sufficient treatment as part of the surface water management train, in accordance with the 2015 SuDS Manual (C753).
- 12.1.13 **Step 3:** The development site is located outside a Source Protection Zone. The water quality approach exceeds requirements. Given this, there is no need for a more pre-cautionary approach.

13 PROPOSED FOUL DRAINAGE

- 13.1 Southern Water's Ford Wastewater Treatment Works (WWTW) is located immediately east of the development site.
- 13.2 The development was first discussed with Southern Water (Stuart Ward, Technical Manager) in September 2018 who advised that Ford WWTW has capacity to receive flows from the development site.
- 13.3 More recent discussions with Southern Water were held on 3 December 2019 (Joff Evadene, Growth Planning Lead, and Luis DaSilva, Planning Co-ordinator) who again confirmed that the Ford WWTW has capacity and that a sewer capacity check for the development is not required.
- 13.4 It is envisaged that the development will be served by at least 4 no. foul water pumping stations that will pump sewage via risings mains directly to the Ford WWTW. An Indicative Foul Water Drainage Strategy is shown on JNP Drawing No. C85228 D107 and D108 in Appendix M. The foul water and surface water drainage strategy drawings were discussed with Southern Water at the meeting on 3 December 2019. Copies of the drawings were sent to Southern Water following the meeting. Southern Water have not raised any objections to the drainage proposals. Further discussion with Southern Water regarding the design of the pumping stations and connections to the WWTW will be undertaken.
- 13.5 3 no. existing number rising mains which run through the site enroute to the Ford WWTW. The proposed site layout for the development has been designed to retain existing rising main routes with no development within easements.
- 13.6 A corridor space through the site to the west of the WWTW has been suggested to Southern Water to provide a route for future new incoming rising mains. The corridor will be greenspace and is shown on JNP Drawing No. C85228-D101 titled Indicative Surface Water Drainage Strategy in Appendix I.

14 MAINTENANCE AND ADOPTION

- 14.1 The main drainage systems will be designed in accordance to Sewers for Adoption. It is envisaged the following onsite drainage components will be adopted by Southern Water.
-  The main surface water sewers
 -  The surface water underground tanks, pumping stations and rising mains
 -  The main foul water sewers
 -  The foul water underground tanks, pumping stations and rising mains
- 14.2 Based on current drainage practice Southern Water will not adopt the attenuation basins. This is current standard practice for all new developments. However, we understand the forthcoming Sewers for Adoption 8th Edition will allow wastewater authorities to adopt certain SuDS features as part of their sewerage network. At this time, we are unable to confirm when Sewers for Adoption 8th Edition will be officially released and operational.
- 14.3 If the attenuation basins remain private they will be managed by a management company to be set up by the developer. Any areas of shared private permeable paving will also be managed by the management company.
- 14.4 Responsibility and maintenance of the surface water infiltration system/ permeable paving will be with individual households where the infiltration system serves a single property.
- 14.5 The main estate roads will be designed in accordance with West Sussex County Council adoptable standards. It is expected that West Sussex County Council will adopt these roads.
- 14.6 The above integrated approach, as required by the Flood & Water Management Act 2010, aims to ensure that there is a clear understanding of drainage responsibilities and that a maintenance regime is implemented for all new drainage systems for the lifetime of the development.

15 CONCLUSIONS

- 15.1 The site covers an area of approximately 86.63 ha. It has an impermeable area of 6 ha comprising of former airfield runways, hardstandings and existing buildings. The remaining 80.63 ha is permeable land in the form of agricultural fields or woodland/ scrub.
- 15.2 The Ford Airfield development site is an allocated strategic housing site (Reference SD8) in the Adoption Arun Local Plan 2011- 2031 (July 2018).
- 15.3 The site has been assessed as follows for flood risk:
-  Fluvial – Low Risk
 -  Tidal – Low Risk
 -  Surface Water (overland flows) – Low Risk
 -  Groundwater – Low Risk
 -  Sewer / Drainage – Low Risk
 -  Reservoir – No Risk
- 15.4 The existing infrastructure at the airfield discharges surface water to the River Arun and Ryebank Rife main rivers by sewer connections to nearby ordinary watercourses.
- 15.5 The drainage strategy prioritises where surface water is discharged in accordance with CIRIA SuDS Manual C753 and the following hierarchy:
-  Infiltration
 -  Discharge to watercourse
 -  Discharge to surface water sewers
- 15.6 Infiltration rate testing was carried out onsite, between 2m and 3m deep and showed that the majority of the site is not suitable for deep infiltration drainage techniques. Slow/ marginal infiltration rates were recorded in the northeast of the development site.
- 15.7 Additional shallow infiltration rate tests excavated between 0.5m and 1.5m below existing ground level, will be carried out to determine if and where permeable paving can be used onsite. This will be considered in more detail during detailed design.
- 15.8 Groundwater monitoring commenced onsite in August 2018 and has been undertaken for more than 12 months. Winter groundwater levels were significantly higher than summer levels by approximately 2.0m. Groundwater levels are highest in the south of the site (BH01 groundwater recorded 0.80m below ground level on 19.12.19) and lowest in the northeast (BH5 groundwater recorded 3.90m below ground level on 19.12.19).
- 15.9 Shallow infiltration drainage cannot be used where groundwater is close to the ground surface and will ingress into the SuDS component. Where soil infiltration rates are 10^{-6} m/s or slower shallow infiltration components can be used but are likely to be excessively deep and large to provide sufficient attenuation for the 100 year + 40%CC storm event.
- 15.10 Where infiltration rates are 10^{-6} m/s or slower it is unlikely shallow infiltration drainage components will

achieve half drain down of storage volume in 24 hours for the 100 year + 40%CC storm event.

- 15.11 ADC has advised that it would expect infiltration to be utilised where infiltration rates are found to be equal to or faster than 10^{-6} m/s. If half drain down times exceed 24 hours for the 1 in 10 year plus climate change event ADC would permit high level overflows to be utilised which permit the discharge of water to watercourse at QBAR.
- 15.12 Based on the marginal infiltration rate results and geotechnical information for the site it is envisaged shallow infiltration alone is not suitable to serve the entire development site for the 1 in 100 year + 40% CC event and it will be necessary to provide surface water sewage systems with attenuation basins which discharge to watercourse.
- 15.13 A catchment analysis has been carried out to determine where existing surface water runoff would discharge to. During a severe storm event it is likely any overland water which flows across the fields would be intercepted and captured by the existing infrastructure and drainage systems which discharge to the River Arun and Ryebank Rife.
- 15.14 It is proposed to utilise the existing connection routes from the development site to the ordinary watercourse which discharge to the River Arun and Ryebank Rife. This is in accordance with the SuDS hierarchy where infiltration alone cannot be used to serve the development.
- 15.15 The attenuation basins have been located in the most suitable locations onsite having assessed design constraints and parameters. This informed the development of the masterplan.
- 15.16 The drainage solution and calculations provided are deemed conservative because the surface water sewers and attenuation basins have been sized to receive surface water runoff from all impermeable areas hardstanding areas across the site. This is currently based on the worst case with no water infiltrating into the ground. Where shallow infiltration is feasible this will enable water to discharge into the ground where it falls and may allow the attenuation basins to reduce in size.
- 15.17 The new development will restrict the flow of water to the existing outfalls to Greenfield runoff rate (QBAR). This provides a reduction and betterment in flow from the site into the downstream drainage systems and watercourse. The onsite drainage system(s) will be designed for the 1 in 100 year + 40% Climate Change event.
- 15.18 The ground levels across the existing development site are generally flat. It will be necessary to raise ground levels in parts of the site to enable gravity sewers onsite to discharge to the attenuation basins.
- 15.19 The maximum rise in ground level in the north of the site is up to 1.0m. Generally, the ground will rise and fall by 0.6m. The maximum rise in ground level in the south of the site is 2.0m at a single localised area. Generally, the ground rises and falls by 0.5m to 1.5m within the developable areas onsite.
- 15.20 Where the depth of the existing site drainage outfall(s) are shallow it will be necessary to pump surface water from the attenuation basin to the outfall. Where possible gravity sewers to the site outfalls will be used, however, this is limited by raising ground levels across the site to facilitate this.
- 15.21 The finished ground levels for the development will be designed so that overland exceedance flows will discharge water from the properties towards the channelized road network. The road network has been designed to channel overland flows towards areas of lesser risk comprising of green corridors, open space and the drainage basins.
- 15.22 As part of the drainage design SuDS systems will be provided to manage and control peak discharge

and treat flows to improve water quality to limit the impact to the water environment.

- 15.23 The development has been discussed with Southern Water who advised that at present Ford WWTW has capacity to receive foul water from the development site.
- 15.24 It is envisaged that the main foul and surface water sewers, pumping stations and rising mains will be adopted by Southern Water. Based on current drainage practice the attenuation basins will be maintained by a management company. Where SuDS systems serve a single property responsibility and maintenance will be with the householder.

16 LIMITATIONS

Discussions and information presented within this report is deemed to be current at the time of undertaking the report. No guarantee can be given to the status of this information other than the time at which this report was written. Where necessary, the user shall confirm the status of any applicable consents and assessments.

This report is confidential and has been prepared solely for the benefit of Wates Developments and Redrow Homes and those parties with whom a warranty agreement has been executed, or with whom an assignment has been agreed. Should any third party wish to use or rely upon the contents of this report, written approval must be sought from jnp group; a charge may be levied against such approval. jnp group accepts no responsibility or liability for the consequence of this document being used for any purpose or project other than for which it was commissioned, or this document being used by any third party with whom an agreement has not been executed.

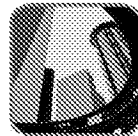
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Appendix A

Topographical Survey & CCTV

Drainage Trace





Existing surface water gullies and foul water connections which serve the Flying Fortress and Arun Sports Arena.

Both buildings will connect to the new drainage systems which will serve the proposed development

Notes:

All information contained in this drawing (including digital data) should be checked and verified by the user.

Digital coordinates are based on the CGNS SRS system.

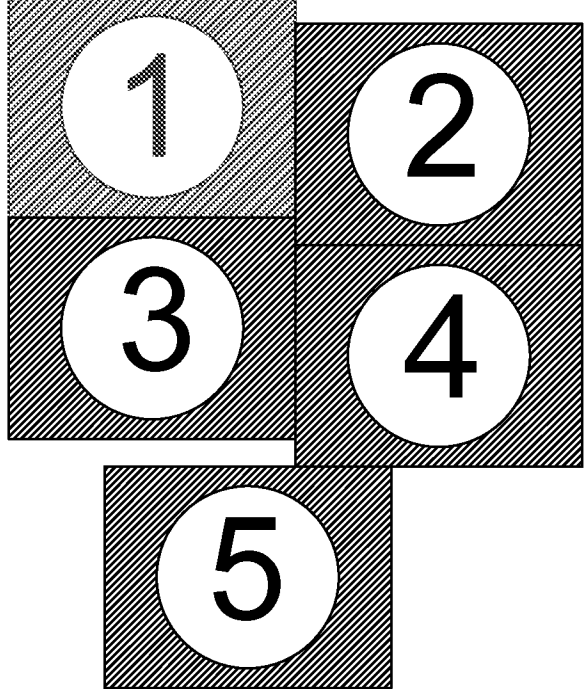
DISCLAIMER: The location of underground services shown on this drawing have been determined from a combination of ground probing radar, where requested) techniques and visual observations. The limitations of this drawing should be noted. It is not guaranteed that all services have been identified. This drawing may not include the location of all public services. If you require more detailed information, service drawings should be obtained from the relevant utility companies or other agencies associated with this drawing. Additional services, structures or other below ground obstructions not indicated on this drawing should be identified and recorded. Drawings should be made to historical plans as built drawings. Excavations in the vicinity of services should be carried out with care. See also document "avoiding dangers from underground services". Location accuracy is determined by the methods used. Manufacturers guidelines for the systems deployed.

All utilities and features have been added to base plan. Please follow a scale hand drawing on site then transferring to cad.

[illegible]

LEGEND			
✓	ARMED ROUTE	08A	OUT SUFFICIENT
✓	ROLLBACK	09A	CONDUIT ROUTE TO BEAD
✓	ROLLBACK	10A	PIE HIDER
✓	ROLLBACK	11A	CONDUIT ROUTE TO BEAD
✓	ROLLBACK	12A	PIE HIDER
✓	ROLLBACK	13A	CONDUIT ROUTE TO BEAD
✓	ROLLBACK	14A	PIE HIDER
✓	ROLLBACK	15A	CONDUIT ROUTE TO BEAD
✓	ROLLBACK	16A	PIE HIDER
✓	ROLLBACK	17A	CONDUIT ROUTE TO BEAD
✓	ROLLBACK	18A	PIE HIDER
✓	ROLLBACK	19A	CONDUIT ROUTE TO BEAD
✓	ROLLBACK	20A	PIE HIDER
✓	ROLLBACK	21A	CONDUIT ROUTE TO BEAD
✓	ROLLBACK	22A	PIE HIDER
✓	ROLLBACK	23A	CONDUIT ROUTE TO BEAD
✓	ROLLBACK	24A	PIE HIDER
✓	ROLLBACK	25A	CONDUIT ROUTE TO BEAD
✓	ROLLBACK	26A	PIE HIDER
✓	ROLLBACK	27A	CONDUIT ROUTE TO BEAD
✓	ROLLBACK	28A	PIE HIDER
✓	ROLLBACK	29A	CONDUIT ROUTE TO BEAD
✓	ROLLBACK	30A	PIE HIDER
✓	ROLLBACK	31A	CONDUIT ROUTE TO BEAD
✓	ROLLBACK	32A	PIE HIDER
✓	ROLLBACK	33A	CONDUIT ROUTE TO BEAD
✓	ROLLBACK	34A	PIE HIDER
✓	ROLLBACK	35A	CONDUIT ROUTE TO BEAD
✓	ROLLBACK	36A	PIE HIDER
✓	ROLLBACK	37A	CONDUIT ROUTE TO BEAD
✓	ROLLBACK	38A	PIE HIDER
✓	ROLLBACK	39A	CONDUIT ROUTE TO BEAD
✓	ROLLBACK	40A	PIE HIDER
✓	ROLLBACK	41A	CONDUIT ROUTE TO BEAD
✓	ROLLBACK	42A	PIE HIDER
✓	ROLLBACK	43A	CONDUIT ROUTE TO BEAD
✓	ROLLBACK	44A	PIE HIDER
✓	ROLLBACK	45A	CONDUIT ROUTE TO BEAD
✓	ROLLBACK	46A	PIE HIDER
✓	ROLLBACK	47A	CONDUIT ROUTE TO BEAD
✓	ROLLBACK	48A	PIE HIDER
✓	ROLLBACK	49A	CONDUIT ROUTE TO BEAD
✓	ROLLBACK	50A	PIE HIDER
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✓	ROLLBACK	52A	PIE HIDER
✓	ROLLBACK	53A	CONDUIT ROUTE TO BEAD
✓	ROLLBACK	54A	PIE HIDER
✓	ROLLBACK	55A	CONDUIT ROUTE TO BEAD
✓	ROLLBACK	56A	PIE HIDER
✓	ROLLBACK	57A	CONDUIT ROUTE TO BEAD
✓	ROLLBACK	58A	PIE HIDER
✓	ROLLBACK	59A	CONDUIT ROUTE TO BEAD
✓	ROLLBACK	60A	PIE HIDER
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✓	ROLLBACK	62A	PIE HIDER
✓	ROLLBACK	63A	CONDUIT ROUTE TO BEAD
✓	ROLLBACK	64A	PIE HIDER
✓	ROLLBACK	65A	CONDUIT ROUTE TO BEAD
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✓	ROLLBACK	67A	CONDUIT ROUTE TO BEAD
✓	ROLLBACK	68A	PIE HIDER
✓	ROLLBACK	69A	CONDUIT ROUTE TO BEAD
✓	ROLLBACK	70A	PIE HIDER
✓	ROLLBACK	71A	CONDUIT ROUTE TO BEAD
✓	ROLLBACK	72A	PIE HIDER
✓	ROLLBACK	73A	CONDUIT ROUTE TO BEAD
✓	ROLLBACK	74A	PIE HIDER
✓	ROLLBACK	75A	CONDUIT ROUTE TO BEAD
✓	ROLLBACK	76A	PIE HIDER
✓	ROLLBACK	77A	CONDUIT ROUTE TO BEAD
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✓	ROLLBACK	79A	CONDUIT ROUTE TO BEAD
✓	ROLLBACK	80A	PIE HIDER
✓	ROLLBACK	81A	CONDUIT ROUTE TO BEAD
✓	ROLLBACK	82A	PIE HIDER
✓	ROLLBACK	83A	CONDUIT ROUTE TO BEAD
✓	ROLLBACK	84A	PIE HIDER
✓	ROLLBACK	85A	CONDUIT ROUTE TO BEAD
✓	ROLLBACK	86A	PIE HIDER
✓	ROLLBACK	87A	CONDUIT ROUTE TO BEAD
✓	ROLLBACK	88A	PIE HIDER
✓	ROLLBACK	89A	CONDUIT ROUTE TO BEAD
✓	ROLLBACK	90A	PIE HIDER
✓	ROLLBACK	91A	CONDUIT ROUTE TO BEAD
✓	ROLLBACK	92A	PIE HIDER
✓	ROLLBACK	93A	CONDUIT ROUTE TO BEAD
✓	ROLLBACK	94A	PIE HIDER
✓	ROLLBACK	95A	CONDUIT ROUTE TO BEAD
✓	ROLLBACK	96A	PIE HIDER
✓	ROLLBACK	97A	CONDUIT ROUTE TO BEAD
✓	ROLLBACK	98A	PIE HIDER
✓	ROLLBACK	99A	CONDUIT ROUTE TO BEAD
✓	ROLLBACK	100A	PIE HIDER

Sheet Layout



SURVEY NOTES

ALL UTILITIES AND FEATURES SHOWN BY S/S HAVE BEEN ADDED TO BASEPLAN BY CREATING A SCALE PLANT DRAWING ON SITE, THEN TRANSFERRING TO S&D.

DOE TO POTENTIAL PROBLEMS/ISSUES THAT MAY ARISE FROM SUCH TECHNIQUES, THE LOCATION OF ALL S/S DRAIN FEATURES MUST BE LOCATED AS INDICATIVE AND AN INITIAL COMPARISON CONDUCTED ON SITE.

Rev. Suffix		Date		Initial		Revision Details				
Surveyor	SS	Verified By	SS	CAD Operator	ARL	Approved By	T.H	Date	30.0	
Levelling		GNSS		Datum		OSGB36				

To an OS GNSS

Client

Barton Wilmore

Location	
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Ford Airfield
Ford, West Sussex

Drawing Title

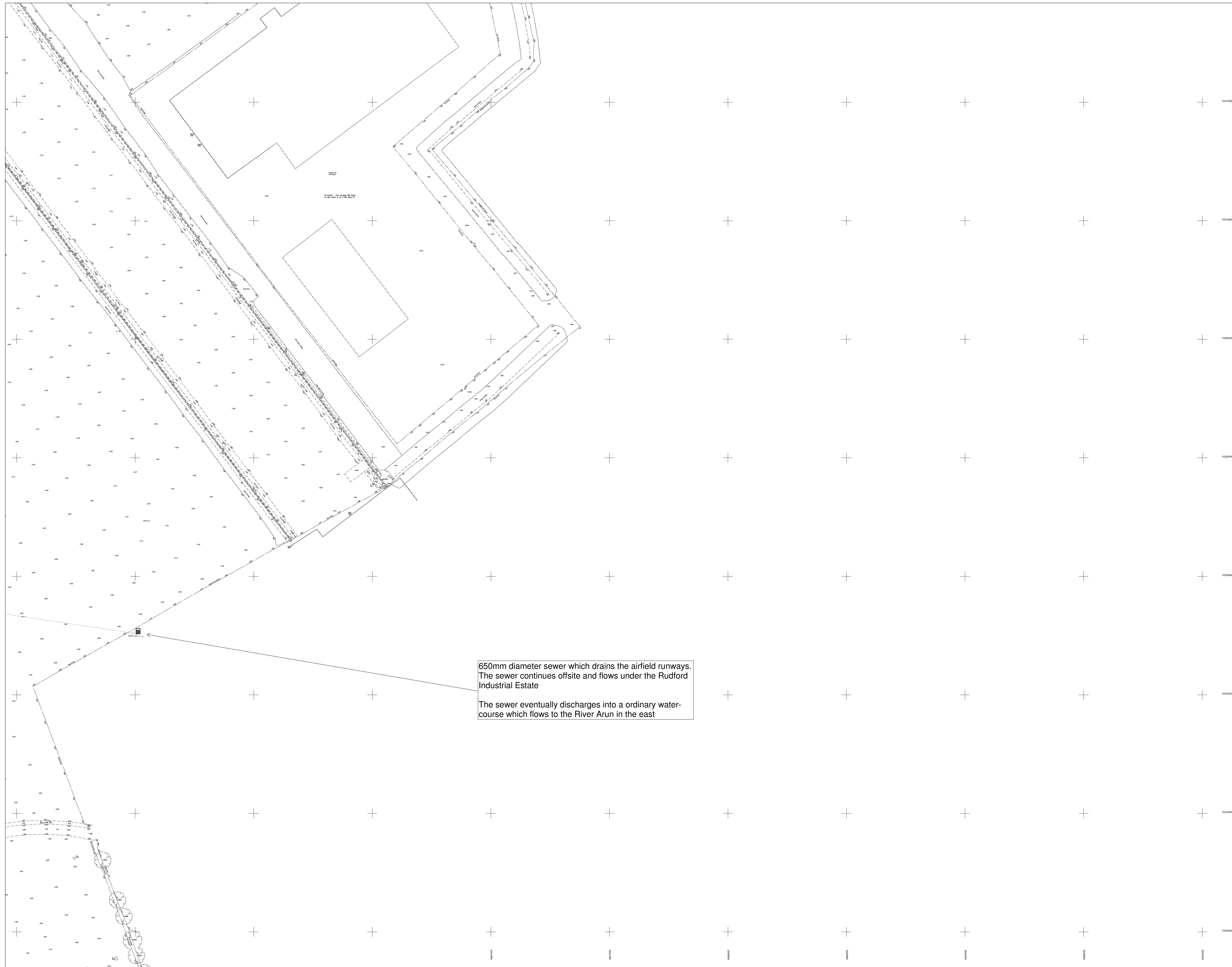
Underground CCTV
Survey - Sheet 1 of 5

Job No. 1812008	Old Job No.
Drawing Number	Revision Suffix

BW/1812008/1	
Scale	Date

1:500m (A0)	January 2019
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notes:

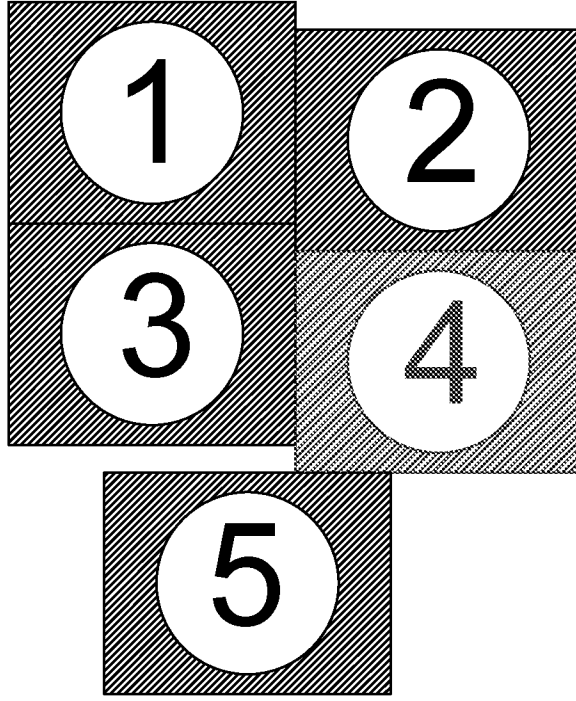
All information contained in this drawing (including digital data) can be checked and verified. The information is provided in the form of hard copy and/or electronic data. The digital coordinates are based on an OS GNS3 system.

DISCLAIMER: The location of underground services shown on this drawing have been determined by the use of ground penetrating radar, (where requested) techniques and visual observations. The limitations of this drawing are that not all services can be located, but all services have been identified. This drawing may not include the location of all public services and may not include the location of all private services. Drawings of underground services provided should be obtained from the appropriate service providers. The information shown on this drawing is for information only and is not to be made to historical plans and as built drawings. Excavations in the vicinity of services should be carried out with care and a "no dig" document "avoiding dangers from underground services". Location accuracy is determined by the manufacturer's guidelines for the systems deployed.

All utilities and features have been added to base map. The drawing is a scale hand drawing on site then transferring to CAD.

[illegible][illegible]

Sheet Layout



SURVEY NOTES

UTILITIES AND FEATURES SHOWN BY SYS HAVE BEEN ADDED TO BASEPLAN BY
 ADDING A SCALE HAND DRAWING ON SITE THEN TRANSFERRING TO CAD.

TO POTENTIAL INADEQUACIES THAT MAY ARISE FROM SUCH TECHNIQUES THE
 DESIGN OF ALL SYS DRAWN FEATURES MUST BE TREATED AS INQUIRATIVE AND ANY
 CAD DIMENSIONS CONFIRMED ON SITE.

Date		Initial		Revision Details				
SS	Verified By	SS	CAD Operator	ARL	Approved By	TJH	Date	30.0
GNSS		Datum		OSGB36				

To an OS GNSS Datum

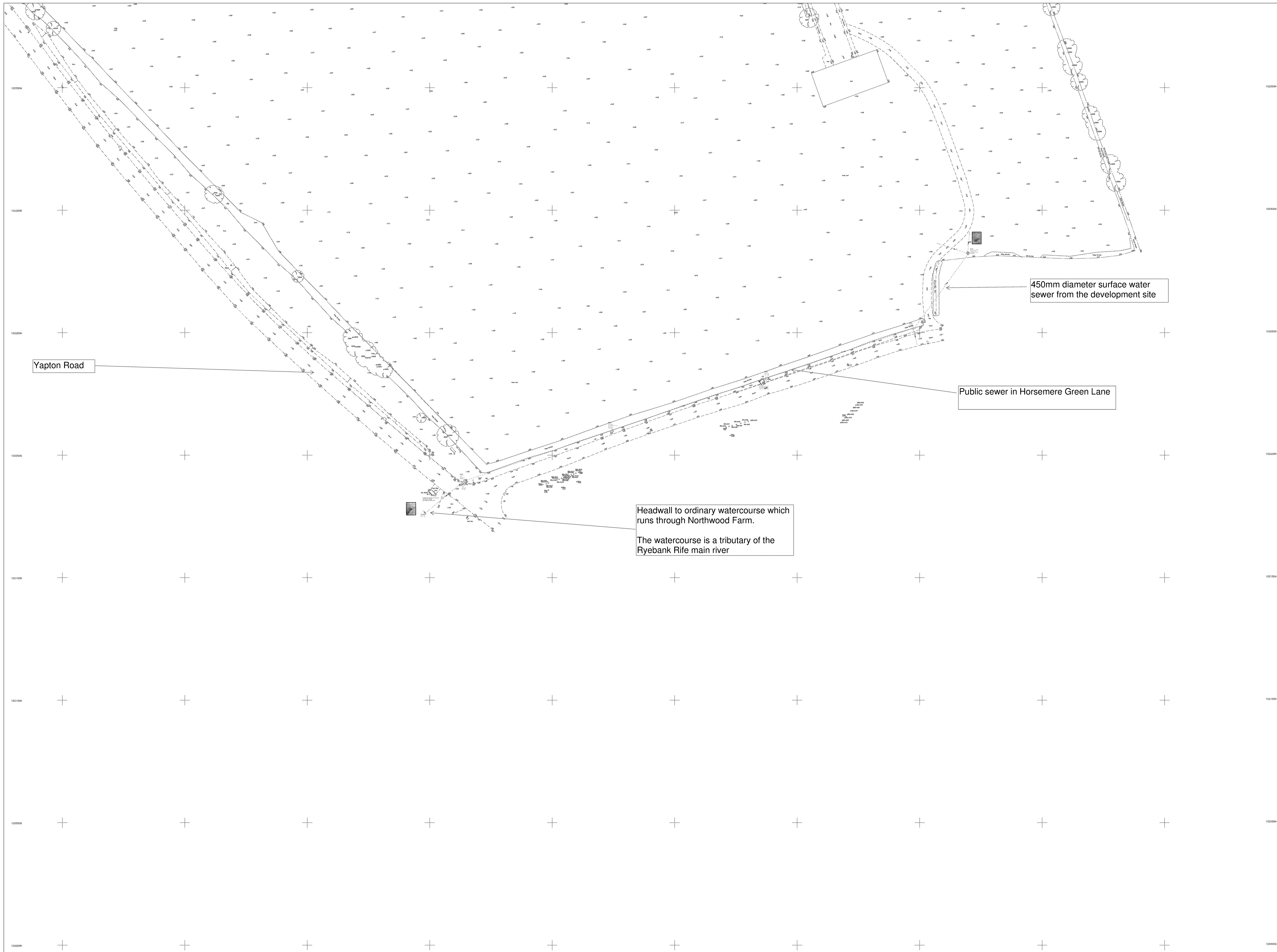
ent

Barton Wilmore

Ford Airfield
Ford, West Sussex

Underground CCTV
Survey - Sheet 4 of 5

Job No. 1812008	Old Job No.
Drawing Number BW/1812008/4	Revision Suffix
Scale 1:500m (A0)	Date January 2019



notes:

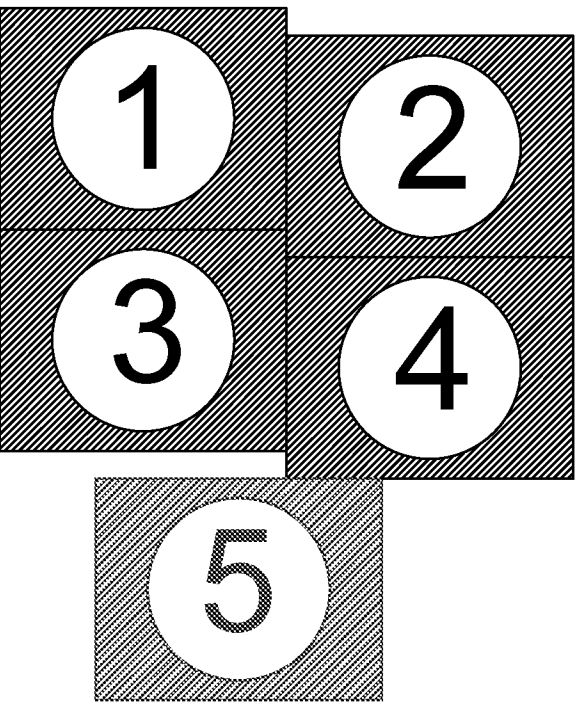
All information contained in this drawing including digital data should be checked and verified and the information contained in the coordinates are based on an US GNSSS system.

DISCLAIMER: The location of underground structures shown in this drawing have been determined by geophysical methods (e.g. ground probing radar, where requested) techniques and visual observations. The limitations of this drawing should be understood and no guarantee can be given that all services have been identified. This drawing may not include the location of all public services and structures that may be present. All service drawings should be obtained from the appropriate responsible authority or corporation with this drawing. Additional services, structures or other below ground obstructions not indicated on this drawing may be present. This drawing should be made to historical plans and as built drawings. Excavations in the vicinity of services should be made in accordance with the AS47 document "avoiding dangers from underground services". Location accuracy is determined by the manufacturer's manufacturers guidelines for the systems deployed.

All utilities and features have been added to base plan. The drawing is a scale hand drawing on a site plan to be transferred to CAD.

[illegible][illegible]

Sheet Layout



SURVEY NOTES

ALL UTILITIES AND FEATURES SHOWN BY SWS HAVE BEEN ADDED TO BASEPLAN BY
CREATING A SHAPE AND CHANGING ON SITE THEN TRANSFERING TO CAD.

DOE TO POTENTIAL INADEQUACIES THAT MAY ARISE FROM SUCH TECHNIQUES THE
LOCATION OF ALL SHOWN FEATURES MUST BE TREATED AS INDICATIVE AND ANY
VERTICAL DIMENSIONS CONFIRMED ON SITE.

Rev. Suffix	Date		Initial		Revision Details					
Surveyor	SS	Verified By	SS	CAD Operator	ARL	Approved By	TJH	Date	30.01.18	
Levelling		GNSS			Datum		OSGB36			

To an OS GNS
Datum

Client

Barton Wilmore

Location

Ford Airfield
Ford, West Sussex

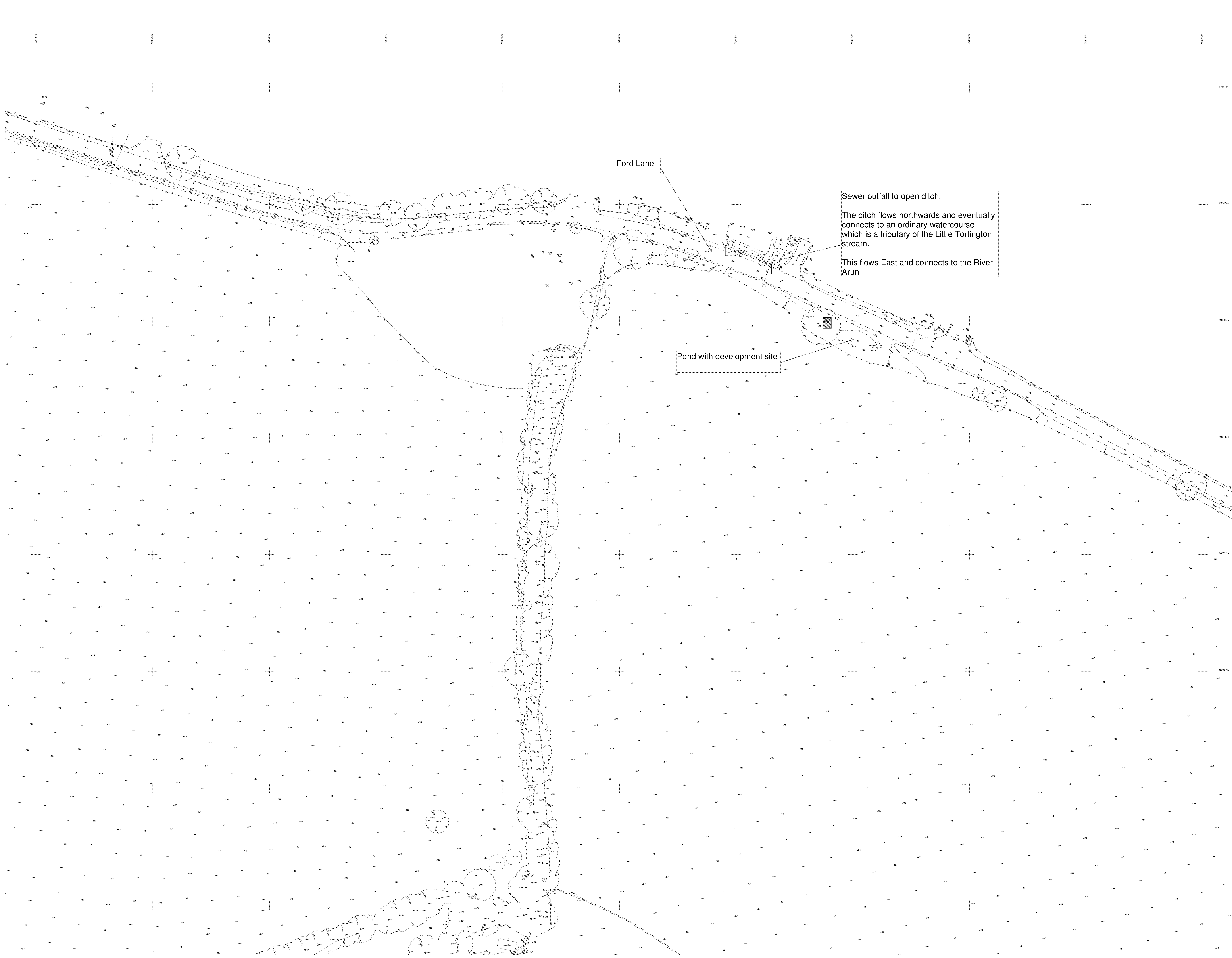
Drawing Title

Underground CCTV
Survey - Sheet 5 of 5

Job No. 1812008	Old Job No.
Drawing Number	Revision Suffix

BW/1812008/5	
Scale	Date

1:500m (A0)	January 2019
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Notes:

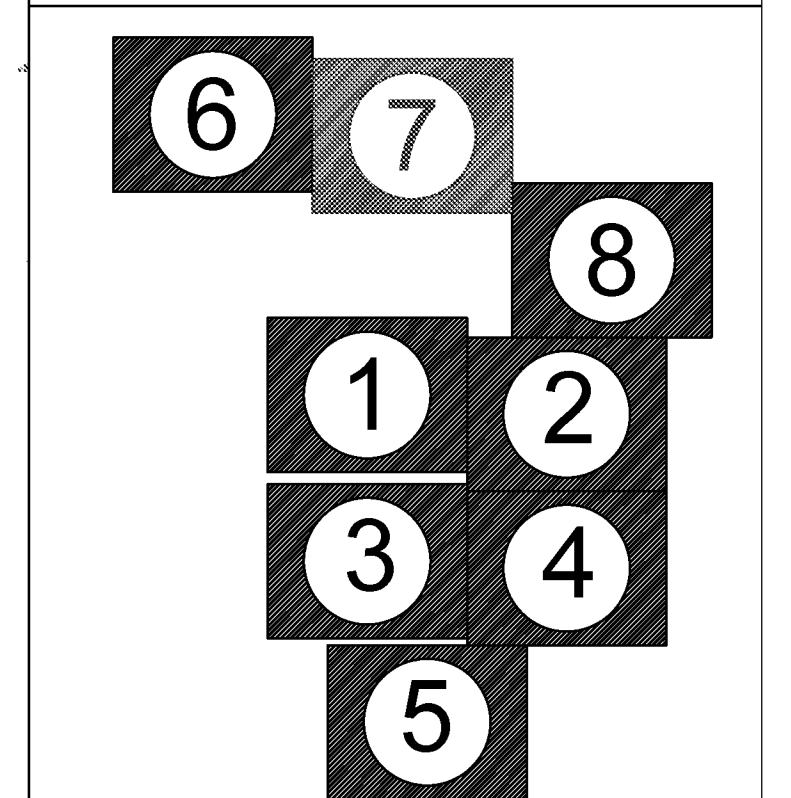
All information contained in this drawing (including digital data) should be checked and verified against the facts of the investigation. Grid coordinates are based on the OS OSNGS system.

DISCLAIMER: The location of underground services shown on this drawing have been determined using electro-magnetic (and/or ground probing) methods (where requested) and/or visual observations. The limitations of this drawing should be realised and no guarantee can be given that all services shown are correct. This drawing may not include the location of all public services that may cross the site and therefore the relevant service providers should be consulted to obtain appropriate utility company and used in conjunction with this drawing. Additional services, structures or other features may be observed on site that are not on this drawing may be present on site. Reference should be made to historical plans and as built drawings. Excavations in the vicinity of services should be carried out with due diligence to HSG47 identifying dangers from underground services. Location accuracy is determined by referring to manufacturers guidelines for the systems deployed.

Use of utilities and features have added to base plan, creating a scale hand drawing on site then transferred to CAD.

[illegible]

Sheet Layout



SURVEY NOTES

[illegible]

A	13.02.19	ARL	Additional information added to survey						
Rev. Suffix	Date	Initial	Revision Details						
Surveyor	SS	Verified By	SS	CAD Operator	ARL	Approved By	TJH	Date	30.01.18
Levelling		GNSS		Datum		OSGB36			

To an OS GNSS Datum

Client
Barton Wilmore

Location	

Ford Airfield
Ford, West Sussex

Drawing Title	Underground CCTV
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Underground Survey - Sheet 7 of 8	
Job No.	1812008
Old Job No.	

Drawing Number BW/1812008/7	Revision Suffix A
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Scale 1:500m (A0)	Date January 2019
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