R. G. PARKINS & PARTNERS LTD

CONSULTING CIVIL & STRUCTURAL ENGINEERS

FLOOD RISK ASSESSMENT AND DRAINAGE STRATEGY

HOUSING DEVELOPMENT

LOW ROAD

WHITEHAVEN

ASTIME PROPERTIES LTD

Revision	Date	Purpose
Original Issue	25/11/2020	Planning

Our ref: K36110/01/FRA/CA

DOCUMENT CONTROL

Project: Housing Development, Low Road, Whitehaven
Project Number: K36110
Project Description: Flood Risk Assessment and Drainage Strategy

Issue	Date	Prepared by	Checked by	Approved by
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Disclaimer

This report was produced by R. G. Parkins & Partners Ltd for Astime Properties Ltd for the specific purpose of providing a Flood Risk Assessment and Drainage Strategy for a Housing Development at Low Road, Whitehaven.

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GLOSSARY OF TERMS

Term	Description
AEP	Annual Exceedance Probability
AOD	Above Ordnance Datum
BGL	Below Ground Level
BGS	British Geological Survey
CC	Climate Change
CCC	Cumbria County Council
DSM	Digital Surface Model
DTM	Digital Terrain Model
EA	Environment Agency
FEH	Flood Estimation Handbook
FFL	Finished Floor Level
FRA	Flood Risk Assessment
GIS	Geographical Information System
LiDAR	Light Detection and Ranging
LLFA	Lead Local Flood Authority
NPPF	National Planning Policy Framework
OS	Ordnance Survey
RGP	R G Parkins and Partners Ltd
SFRA	Strategic Flood Risk Assessment
SuDS	Sustainable Drainage System
UU	United Utilities

1.0 INTRODUCTION

1.1 Background

This following report has been prepared by R. G. Parkins & Partners Ltd (RGP) for Astime Properties Ltd in support of proposals for a residential development comprising of 99 dwellings at Low Road, Whitehaven.

RGP has been appointed to undertake a Flood Risk Assessment and Outline Surface and Foul Water Drainage Strategy in accordance with the National Planning Policy Framework (NPPF) to support a planning application that fulfils the requirements of the Local Planning Authority, the Lead Local Flood authority and the Sewerage Undertaker.

The following study assesses flood risk to the site and proposed development and demonstrates the proposed development will not adversely affect flood risk elsewhere.

1.2 Planning Policy

The NPPF [1] and its Planning Practice Guidance [2] states “a site-specific flood risk assessment should be provided for all development in Flood Zones 2 and 3. In Flood Zone 1, an assessment should accompany all proposals involving: sites of 1 hectare or more; land which has been identified by the Environment Agency as having critical drainage problems; land identified in a strategic flood risk assessment as being at increased flood risk in the future; or land that may be subject to other sources of flooding, where its development would introduce a more vulnerable use.”

The development is classed as major development in accordance with The Town and Country Planning Order 2015 [3], due to the development comprising of more than 10 dwellings.

1.3 The Development in the Context of Planning Policy

The area covered by the application is 3.425ha (hectares) and by reference to the Environment Agency Flood Map, the site lies in Flood Zone 1. The latest site layout plan by Green Swallow Architect’s (drawing number 10902/01) is included in Appendix A for reference.

Table 2 of the NPPF’s Planning Practice Guidance [2] classifies each development into a vulnerability class, depending on the type of development, as outlined in Table 1.1. As residential dwellings the site is classified as ‘More vulnerable’. ‘More Vulnerable’ development classes are deemed acceptable in terms of flood risk within Flood Zone 1. However due to the site exceeding 1 ha, a Flood Risk Assessment is required.

Table 1.1 Flood Risk Vulnerability Classification

Vulnerability Classification	Development
Essential Infrastructure	• Essential transport infrastructure (including mass evacuation routes) which has to cross the area at risk • Essential utility infrastructure, which has to be located in a flood risk area for operational reasons, including electricity generating power stations and grid and primary substations; and water treatment works that need to remain operational in times of flood • Wind turbines
Highly Vulnerable	• Police and ambulance stations; fire stations and command centres; telecommunications installations required to be operation during flooding. • Emergency dispersal points • Basement dwellings • Caravans, mobile homes and park homes intended for permanent residential use • Installations requiring hazardous substances consent
More Vulnerable	• Hospitals • Residential institutions such as residential care homes, children's homes, prisons and hostels. • Buildings used for dwelling houses, student halls of residence, drinking establishments, nightclubs and hotels. • Non-residential uses for health services, nurseries and education establishments. • Landfill and sites used for waste management facilities for hazardous waste. • Sites used for holiday or short let caravans and camping, subject to a specific warning and evacuation plan
Less Vulnerable	• Police, ambulance and fire stations which are NOT required to be operational during flooding. • Buildings used for shops; financial, professional and other services; restaurants, cafes and hot food takeaways; offices; general industry, storage and distributions; non-residential institutions not included in the 'more vulnerable' class; and assemble and leisure. • Land and buildings used for agriculture and forestry • Waste treatment (except landfill & hazardous waste facilities) • Minerals working & processing (except for sand & gravel working) • Water treatment works which do not need to remain operational during times of flood • Sewage treatment works, if adequate measures to control pollution and manage sewage during flooding events are in place.
Water-Compatible Development	• Flood control infrastructure • Water transmission infrastructure & pumping stations • Sewage transmission infrastructure & pumping stations • Sand & gravel working • Docks, marinas and wharves • Navigation facilities • Ministry of Defence installations • Ship building, repairing & dismantling, dockside fish processing & refrigeration & compatible activities requiring a waterside location • Water based recreation (excluding sleeping accommodation) • Lifeguard and coastguard stations • Amenity open space, nature conservation & biodiversity, outdoor sports and recreation and essential facilities such as changing rooms • Essential ancillary sleeping or residential accommodation for staff required by uses in this category subject to a specific warning & evacuation plan.

2.0 SITE CHARACTERISATION

2.1 Site Location

The proposed site is located approximately 1.5km south of Whitehaven town centre, to the west of Low Road (B5345) at National Grid Co Ordinates 297533E 516334N. The site's location is shown below in Figure 2.1.

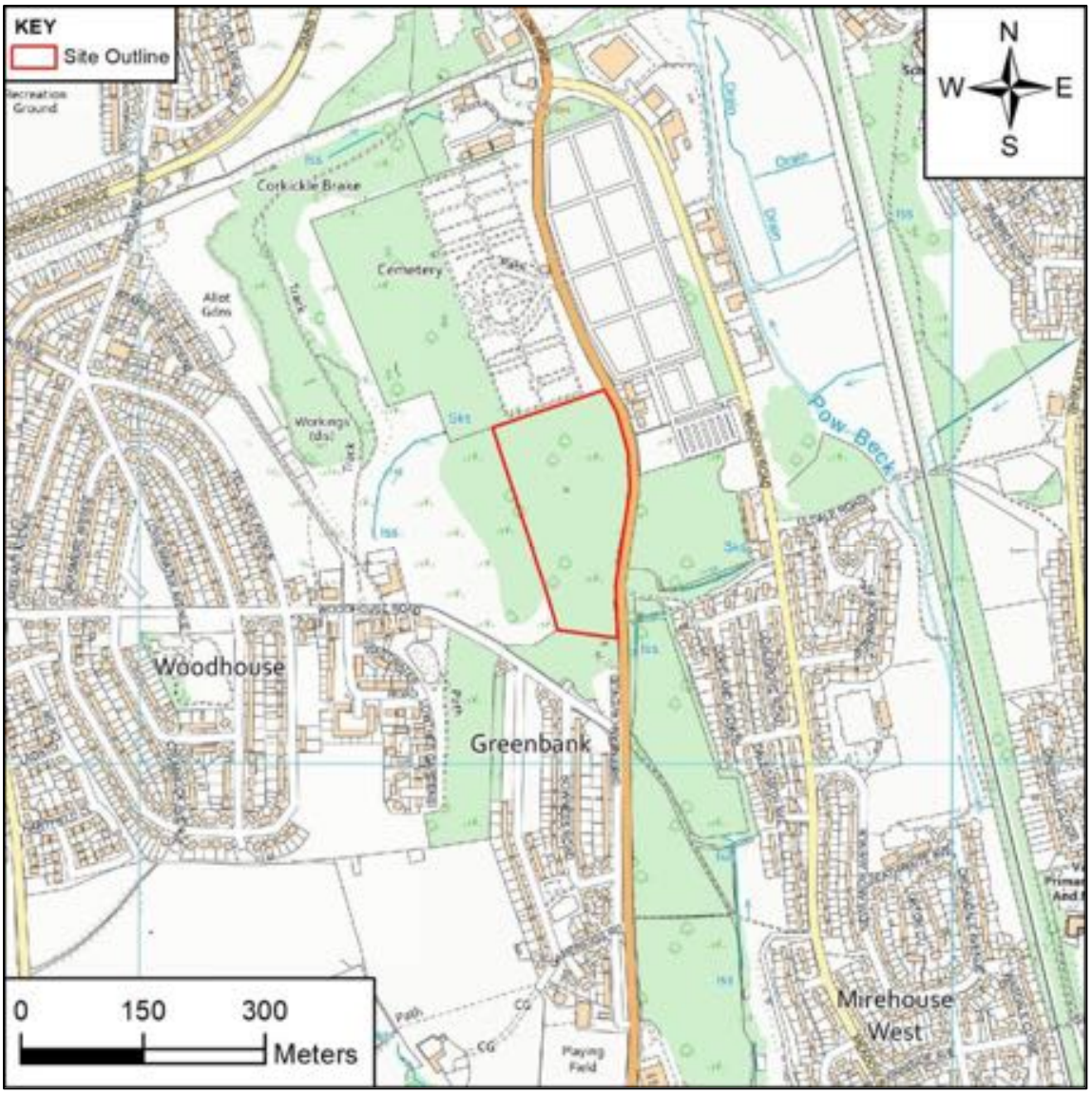

Figure 2.1 Site Location

2.2 Site Description

We have designated the site as Greenfield for pre-development surface water runoff calculation purposes, but this does not reflect the planning land use which is designated as a Brownfield site. The site is considered Greenfield as although part of the site was formerly occupied by the historically

demolished Whitehaven Workhouse and Infirmary, no buildings exist on the site which has been vacant for a considerable period of time and now resembles scrubland, and no existing outfall drainage connections from the historic structures have been proven from the site. The site boundary covers approximately 3.425ha and at present is unused. The site is bounded with a retaining wall to Low Road to the east and Whitehaven Cemetery to the north. To the south and western boundaries are areas of open scrubland beyond which lies the Woodhouse and Greenbank Housing Estates.

Topographically, the site slopes typically from west to east with a lesser fall to the north. Surface levels are relatively flat in the central and eastern part of the site in the area occupied by the old workhouse (around 40.00 mAOD). Ground levels across the western side of the site vary between a high point of approximately 51.00 mAOD at the south west falling to 31.00 mAOD towards the north eastern site boundary. There are some steep cuttings visible within the site where alterations have taken place to allow for historic site developments of the old workhouse and associated buildings. The land beyond the western boundary falls steeply for approx. 300m towards Fell View Avenue

2.3 Geology & Hydrogeology

British Geological Survey (BGS) [4] and Land Information Systems (LandIS) [5] mapping indicates the site is underlain by the geological sequences outlined in Table 2.1. The EA Groundwater Vulnerability Map [6] indicates the nearest Groundwater Source Protection Zone is a Zone 3 which is situated approximately 4 km south east of the site. The development site overlies a secondary aquifer with 'High' vulnerability.

Table 2.1 Site Geological Summary

Geological Unit	Classification	Description	Aquifer Classification
Soil	Soilscape 6	Freely draining slightly acid loamy sails	N/A
Drift	Till, Devensian - Diamicton	Sediments laid down by the direct actions of glacial ice	**Summary:** Secondary
Solid	Pennine Middle Coal Measures Formation	Mudstone, Siltstone and Sandstone	**Summary:** Secondary A

2.4 Existing Watercourses

The closest surface water features are two issues located to the west and south of the site and two sinks located to the north west and east of the site. The western sink and issue are of significance to the surface water hydrology of the site as discharge from the issue flows into an open channel following a curving path to the south-western corner of the cemetery into a culvert that appears to run along the boundary line between the cemetery and the proposed development site flowing north east and continuing to eventually outfall into the nearest main river Pow Beck which flows

northwards, approx. 0.2km east of the proposed development site. Further drainage investigations and a CCTV survey were carried out on this watercourse in March 2019, which found the existing culvert to be in poor condition. The findings are discussed in more detail in Section 3.9.

2.5 Existing Sewers

Reference to the United Utilities sewer records indicates that there are no sewers crossing the site. The closest combined sewer is a 150mm diameter pipe, situated within Low Road at the north east corner of the site flowing north for a short length before heading east and connecting to a larger 225mm diameter combined sewer running along Meadow Road.

The sewer records also indicate that within a new residential development (Jefferson Park) approx. 375m to the north of the site off Low Road, there are foul and surface water sewers present which appear to discharge into existing combined and surface water sewers located at the junction between Low Road and Meadow Road.

RGP instructed Drain Doctor to further investigate the sewers in this location and on the 25 February 2020 a CCTV survey (Appendix C) was carried out. This found the private drainage servicing Jefferson Park would be unsuitable and it was therefore determined that any surface water drainage from the new development would need to bypass this system and connect independently to the existing culverted watercourse located in this area.

The investigations confirmed the presence of this culverted watercourse running in a north westerly direction located at the northernmost manhole indicated on the existing UU records. Dye testing confirmed that this culvert eventually outfalls downstream to Pow Beck and would therefore appear to provide the most suitable connection point for attenuated surface water runoff from the proposed development.

2.6 Ground Conditions

RGP instructed EP3 to carry out soakaway tests on the site to establish the ground conditions and soil infiltration characteristics. EP3 attended the site on the 24th June 2019 and a series of 3 No. mechanically and 1 No. hand excavated trial pits were undertaken to maximum depths of between 0.5m and 2m. The ground conditions typically consisted of superficial deposits of stiff to very stiff brown/grey clays. Solid bedrock was not encountered during the intrusive ground investigations.

Groundwater was encountered during the intrusive ground conditions in trial pits 1 & 2 positioned near the centre of the site and as such it was not possible to complete any percolation tests in these pits.

In addition to this, EP3 undertook 2 no. percolation tests in the north western trial pits 3 & 4. Both tests failed to return a result which demonstrated that the underlying strata is highly impermeable. As a result, the use of soakaway drainage systems is not considered viable for the development.

It was also noted that the northeast corner of the site is a topographical low point and likely acts as a sump for wider site run-off. Similarly, this sector has been identified as a marsh area on the topographical survey.

3.0 ASSESSMENT OF FLOOD RISK

3.1 Background

The following risk assessment has been carried out in accordance with the National Planning Policy Framework [1] and its Planning Practice Guidance [2] on Flood Risk. The broad aim of the guidance is to reduce the number of people and properties within the natural and built environment at risk of flooding. To achieve this aim, planning authorities are required to ensure that flood risk is properly assessed during the initial planning stages.

Responsibility for this assessment lies with the developers and they must demonstrate:

- Whether the proposed development is likely to be affected by flooding.
- Whether the proposed development will increase flood risk in other parts of the hydrological catchment.

That the measures proposed to deal with any flood risk are sustainable. The developer must prove to the Local Planning Authority, Lead Local Flood Authority and the Environment Agency that the existing flood risk or the flood risk associated with the proposed development can be satisfactorily managed.

3.2 Flood Risk Terminology

Flood risk considers both the probability and consequence of flooding.

Flood events are often described in terms of their probability of recurrence or probability of occurring in any one year. The threshold between a medium flood and a large flood is often regarded as the 1 in 100-year event. This is an event which statistical analysis suggests will occur on average once every hundred years. However, this does not mean that such an event will not occur more than once every hundred years. Table 3.1 shows the event return periods expressed in years and annual exceedance probabilities as a fraction and a percentage.

For example, a 1 in 100-year event has a 1% probability of occurring in any one year, i.e. a 1 in 100 probability. A 1000-year event has a 0.1% probability of occurring in any one year, i.e. a 1 in 1000 probability.

Table 3.1 Flood Return Periods and Exceedance Probabilities

Return Period (years)	Annual Exceedance Probability (AEP)	
	Fraction	Percentage
2	0.5	50%
10	0.1	10%
25	0.04	4%
50	0.02	2%
100	0.01	1%
200	0.005	0.5%
500	0.002	0.2%
1000	0.001	0.1%

3.3 Data Collection

The following information was referred to for the Flood Risk Assessment:

- Environment Agency Flood Map for Planning covering the site and adjacent area
- Environment Agency Surface Water Flood Risk Map
- Environment Agency Reservoir Flood Risk Map
- Environment Agency Historic Flood Map
- United Utilities sewer records
- British Geological Survey Groundwater Flooding Susceptibility Map
- Copeland Borough Council Strategic Flood Risk Assessment
- Development layout plan provided by Green Swallow Architects (Appendix A)

3.4 Environment Agency Flood Map for Planning

The Environment Agency Flood Map for Planning [6] (Figure 3.1) has been reviewed to assess the level of flood risk to the area. The flood map shows areas that may be at risk of fluvial flooding in a 1% (1 in 100 year, dark blue) or 0.1% (1 in 1000 year, light blue) Annual Exceedance Probability (AEP) event. Alternatively, if the flood risk is tidal the flood map will show areas predicted to be at risk of flooding from the sea in a 0.5% AEP event (1 in 200 year, dark blue) or a 0.1% AEP event (1 in 1000 year, light blue).

The Flood Map shows the current best information on the extent of the extreme flood from rivers or the sea that would occur without the presence of flood defences. The potential impact of climate change is not considered by the mapping.

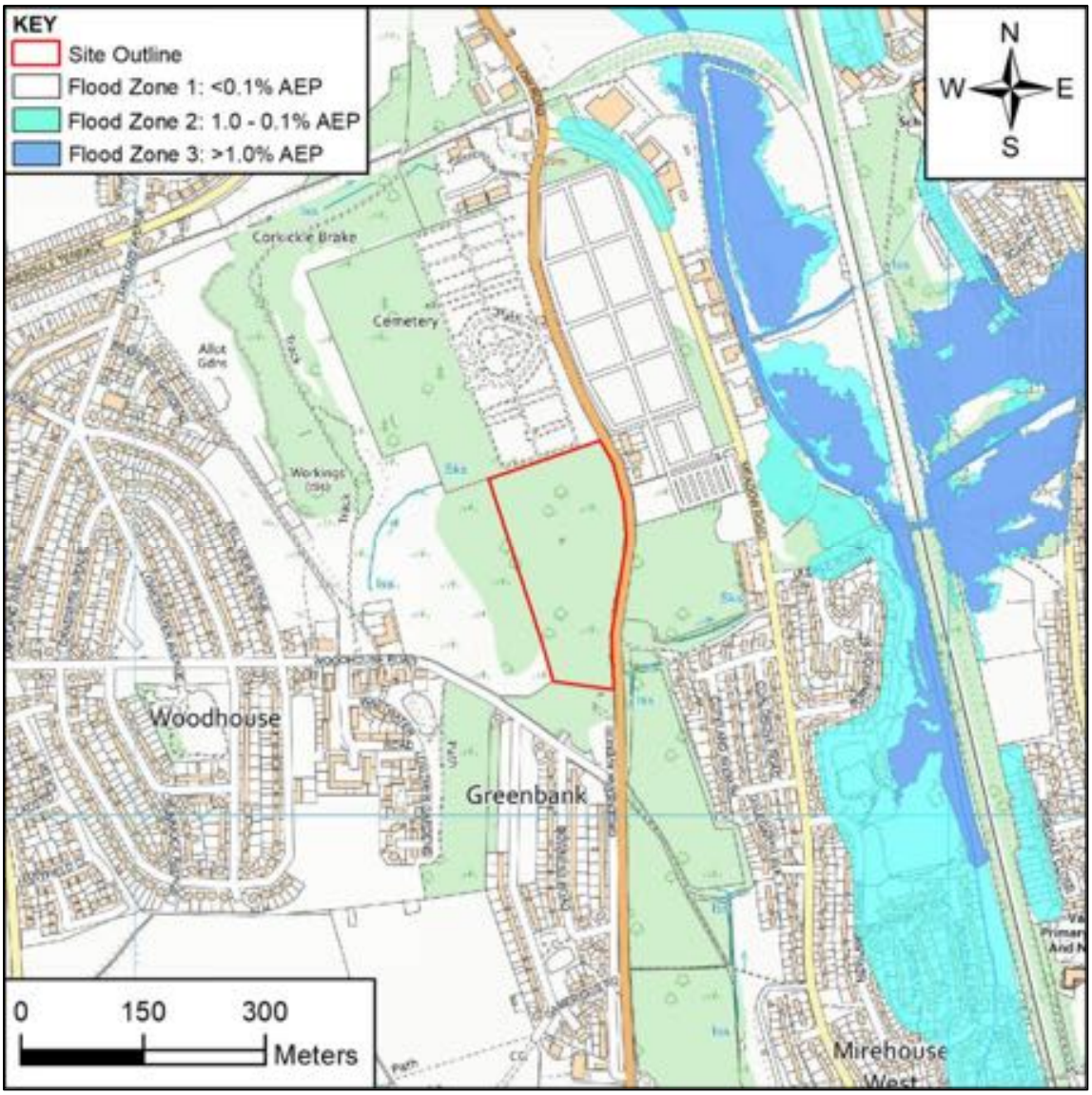

Figure 3.1 Environment Agency Flood Map for Planning

Reference to Figure 3.1 indicates the site lies within Flood Zone 1 “Low Probability”, land assessed as having a less than 0.1% annual probability of flooding (i.e., rivers, lake or sea) in any year by reference to the NPPF.

3.5 Strategic Flood Risk Assessment (SFRA)

Copeland Borough Council undertook a SFRA (Strategic Flood Risk Assessment) in 2007 [7] which refers to the Environment Agency Flood Maps to determine flood risk.

It states there are several historic flooding incidents in Whitehaven, but these are generally attributed to tidal flooding due to the proximity of the town centre to the coastline. Some properties are at risk from the main watercourse, Pow Beck which bisects the town and during extreme events, flooding

can be exacerbated in certain areas by insufficient sewer capacities. This site however is located away from the historically affected areas and is not shown to be at risk of flooding.

3.6 Surface Water Flood Risk

The EA have mapped areas prone to surface water flooding based on historic flooding information received from the Lead Local Flood Authority and modelling based on a LiDAR / IfSAR digital terrain model, Ordnance Survey information on urban areas and a direct rainfall approach using Flood Estimation Handbook (FEH) methodology. The critical (worst case) of the 1, 3 and 6-hour storm durations have been mapped with no areal reduction factor applied. No allowance is made for climate change, the mapping therefore indicates the current predicted flood risk.

The maps do not account for culverts / underground drainage and due to digital terrain model resolution may also underestimate or omit small drainage channels / ditches. Figure 3.2 shows the resulting predicted flood risk from surface water.

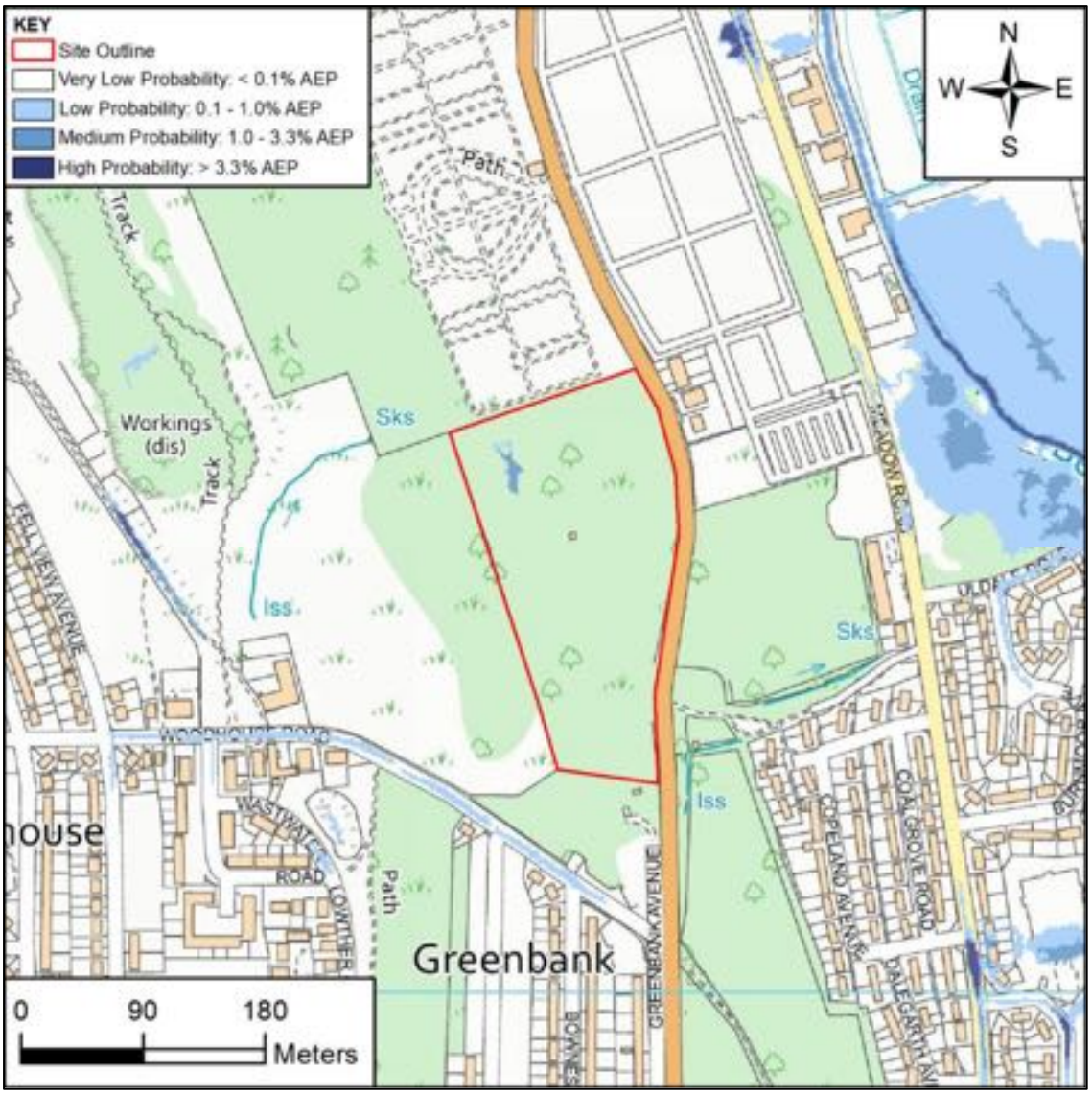

Figure 3.2 Environment Agency Surface Water Flood Map

The EA surface water flood map indicates the site is 'Very Low' risk of surface water flooding. The risk of flooding is less than 0.1% AEP (1 in 1000 year), with a very minor portion at medium risk in the north west of the site, this could be due to the run off from the steep sloping topography above the west of the site over an area believed to be impervious soil.

The western Issue, sink and associated open channel has a 'Very Low' (less than 0.1% AEP) probability of surface water flooding, this however then enters a culvert not shown on the EA surface water maps that runs along the northern boundary of the site under the cemetery which required further investigation discussed in Section's 2.4 and 3.9.

Currently, surface water run-off from the site is directed towards Low Road due to the sloping topography. Any development resulting in an increase in impermeable areas could cause additional run-off if not properly managed. It is therefore proposed to incorporate sufficient SuDS measures to

mitigate this as part of the overall Drainage Strategy. This is discussed in further detail in Section 4.0.

3.7 Groundwater Flood Risk

British Geological Survey (BGS) records (Figure 3.3) show the majority of the site lies within an area of 'Limited Potential for Groundwater Flooding to Occur'. In the north of the site there is 'Potential for Groundwater Flooding of Property Situated Below Ground Level'. A small portion of the site in the north east indicates a 'Potential for Groundwater Flooding to Occur at Surface'. The dataset shows areas susceptible to groundwater flooding, but it does not indicate the likelihood of it occurring.

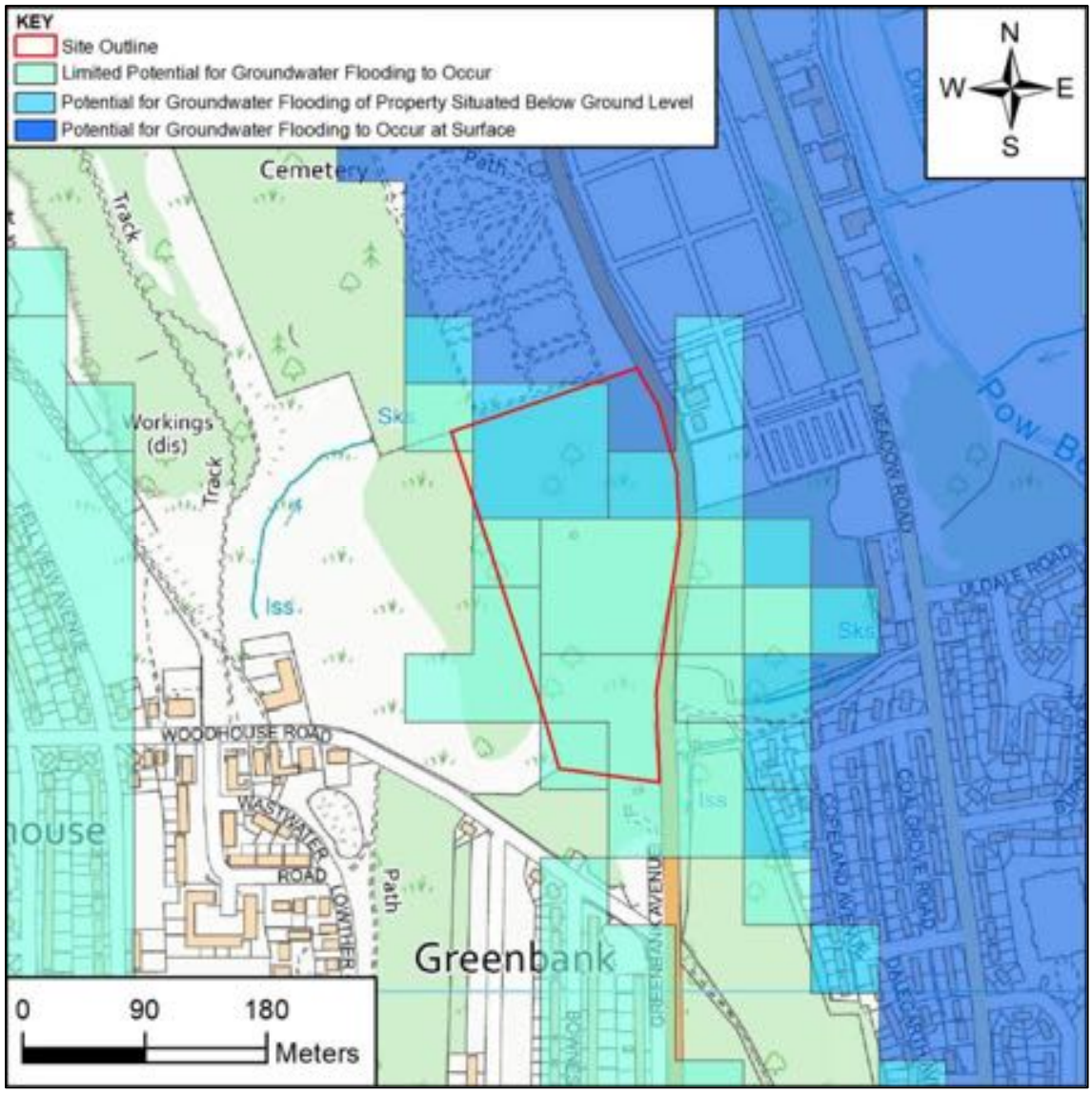

Figure 3.3 BGS Groundwater Flooding

As noted in the Ground Investigation the northeast sector of the site is a topographical low point and likely acts a sump for wider site run-off.

3.8 Flooding from Reservoirs, Canals or Other Artificial Sources

The Ordnance Survey map indicates that there are no reservoirs, canals or artificial structures in the proximity of the proposed development site.

3.9 Flooding from Sewers and Culverts

United Utilities (UU) do not provide information on flood risk from their assets and there have been no reports within the SFRA.

As further investigation of the known culvert running along the northern boundary was required, RGP instructed Mayson Bros Ltd, to carry out a CCTV drainage survey on the culvert on the 19th March 2019 to ascertain the condition and path of the drainage culvert from the point of entry of the open channel at the south west of the cemetery.

The CCTV drainage survey report (Appendix C) indicates that the section of the culvert running through the cemetery is damaged and suffers from cracked pipes and root ingress. Further downstream the culvert pipe is broken and collapsed. These blockages likely result in water backing up and overtopping into the open watercourse adjacent to the site. It will therefore be necessary to ensure that the culvert pipe within the development site is repaired/replaced and that potential exceedance flows are properly managed to ensure that none of the new properties are at risk of flooding.

To safeguard the local area and future proof the existing culvert it is recommended that the LLFA liaise directly with the downstream Riparian owners to undertake the necessary repairs.

4.0 SURFACE WATER DRAINAGE STRATEGY

4.1 Introduction

The principal aim of the following drainage strategy is to design the development to avoid, reduce and delay the discharge of rainfall to public sewers and watercourses in order to protect watercourses and reduce the risk of localised flooding, pollution and other environmental damage.

In order to satisfy these criteria this surface water runoff assessment and drainage design has been undertaken in accordance with the following reports and guidance documents:

- SuDS Manual, CIRIA Report C753, 2015 [9].
- Code of practice for surface water management, BS8582:2013, November 2013. [10]
- Rainfall runoff management for developments, Defra/EA, SC 030219, 2013 [11].
- Designing for Exceedance in Urban Drainage – good practice, CIRIA Report C635, 2006 [12].
- Flood Estimation Handbook (FEH) [13].
- Flood Studies Report (FSR), Volume 1, Hydrological Studies, 1993 [14].
- Flood Studies Supplementary Report No 14 (FSSR14), Review of Regional Growth Curves, 1983 [15].
- Flood Estimation for Small Catchments, Marshall & Bayliss, Institute of Hydrology, Report No. 124 (IoH 124), 1994 [16].
- Water UK, Design and Construction Guidance for Foul & Surface Water Sewers, Approved Version 2.0, March 2020. [17]

The following assessment and drainage strategy is based on the latest site layout plan by Green Swallow Architect's included in Appendix A.

Any alterations to the site plan resulting in changes to impermeable areas will require the drainage strategy to be revisited.

4.2 Site Areas

To support the exploration of options for site drainage, the spatial extent of different types of proposed land cover on the site have been measured.

Table 4.1 shows the measured proposed land cover areas. The highest percentage is garden areas at 46% of the total site area. Housing covers 20%, parking areas 17% and roads 17%.

Table 4.1 Land Cover Areas

Land Cover	Area		Percentage of total site area
	m^2	Ha	
Total housing roof area	6689.5	0.669	20%
Total parking and paved area	5943.9	0.594	17%
Total road area	5751.5	0.575	17%
Garden areas	15865.1	1.587	46%

The site can be subdivided into land cover that could be permeable and that which could be impermeable. Potential impermeable areas are regarded as housing, parking, roads, driveways and walkways. All other areas (principally gardens) are regarded as having a permeable surface. Table 4.2 gives the areas of potentially permeable and impermeable land cover and this shows that impermeable areas could cover 54% of the site and permeable areas 46%.

Table 4.2 Area of Potentially Impermeable & Permeable Land Cover

Land Cover	Area		Percentage of total site area
	m^2	Ha	
Total impermeable area	18384.9	1.838	54%
Remaining permeable area	15865.1	1.587	46%

4.3 Surface Water Drainage Design Parameters

The surface water drainage system has been designed on the following basis using the modified rational method and a generated rainfall profile:

4.3.1 Climate Change

Projections of future climate change indicate that more frequent short-duration, high intensity rainfall and more frequent periods of long-duration rainfall are likely to occur over the next few decades in the UK. These future changes will have implications for river flooding and for local flash flooding. These factors will lead to increased and new risks of flooding within the lifetime of planned developments.

Current climate change guidance issued by the Environment Agency came into effect outlining the anticipated changes in extreme rainfall intensity.

Table 4.3 shows anticipated changes in extreme rainfall intensity in small and urban catchments. Guidance states that for site-specific flood risk assessments and strategic flood risk assessments,

both the central and upper end allowances should be assessed to understand the range of impacts. A climate change allowance of 40% has been selected for the purpose of drainage design based on the 100-year anticipated design life of the proposed development in accordance with LLFA requirements. No properties are located immediately downstream of the site and therefore the site poses low risk to neighbouring property.

Table 4.3 Peak Rainfall Intensity Allowance in Small and Urban Catchments (use 1961 to 1990 baseline)

Applies across all of England	Total potential change anticipated for the '2020s' (2015 to 2039)	Total potential change anticipated for the '2050s' (2040 to 2069)	Total potential change anticipated for the '2080s' (2070 to 2115)
Upper end	10%	20%	40%
Central	5%	10%	20%

4.3.2 Urban Creep

BS 8582:2013[10] outlines best practice with regard to Urban Creep. Although not a statutory requirement, future increase in impermeable area due to extensions and introduction of impervious positively drained areas has been considered. An uplift of 10% on impermeable areas associated with plots only (excluding roads) has been applied to the contributing area.

The inclusion of 10% is highly conservative due to the provision of adequate parking on the site and the density of the properties.

4.3.3 Percentage Impermeability (PIMP)

The percentage impermeability (PIMP) for all impermeable areas is modelled as 100%. The entirety of the impermeable areas is to be positively drained.

4.3.4 Volumetric Runoff Coefficient, Cv

The volumetric runoff coefficient describes the volume of surface water which runs off an impermeable surface following losses due to infiltration, depression storage, initial wetting and evaporation. The coefficient is dimensionless. Default industry standard volumetric runoff coefficients are 0.75 for summer and 0.84 for winter.

4.3.5 Rainfall Model

The calculations use the REFH2 unit hydrograph methodology in line with best practice as outlined in the SuDS Manual [9]. The calculations use the most up to date available catchment descriptors (2013) provided by the Centre for Ecology and Hydrology Flood Estimation Handbook web service.

4.4 Surface Water Disposal

Surface water disposal has been considered in line with the hierarchy outlined in the Non-Statutory Technical Standards [8] and SuDS Manual [9]. The approach considers infiltration drainage in preference to disposal to watercourse, in preference to discharge to sewer.

4.4.1 Infiltration

Infiltration testing indicates underlying soil on the site is unsuitable for the disposal of surface water by this method. For further information refer to Section 2.0.

4.4.2 Positive Drainage

The entire impermeable area of the site will require a positive drainage solution.

In line with the SuDS hierarchy for surface water disposal, discharge of surface water shall be connected downstream via a new pipe network in Low Road to the existing culverted surface water drain which discharges to the nearest watercourse Pow Beck.

4.5 Pre-development Rate of Runoff Assessment

Due to site constraints, it will be necessary to positively drain the entire impermeable area of the site. The total site area is 3.425 ha (34,250 m^2). Following development, the proposed impermeable area to be positively drained is 18,385m^2. The area of highway requiring separate positive drainage shall be 5,752m^2.

As discussed in Section 2.2 the site has been designated as Greenfield for predevelopment surface water runoff calculation purposes, but this does not reflect the planning land use which is designated as a Brownfield site.

The site is less than 200 ha therefore the Greenfield calculations have been undertaken in accordance with methodology described in IoH 124 [16]. For catchments of less than 50ha the Greenfield runoff rate is scaled according to the size of the catchment in relation to a 50 ha site. Currently the site is undeveloped (greenfield) and used for grazing.

Full details of the calculations and the methodology for deriving the Peak Rate of Runoff are in included in Appendix B. A summary of the results is included in Table 4.4.

Table 4.4 Greenfield Rate of Runoff Results – Entire development

Rate of Run-Off (l/s)	
Event	**Greenfield**
Q1	13.1
QBAR	15.1
Q10	20.8
Q30	25.7
Q100	31.4
Q100 + 40% CC	44.0

Without attenuation, the proposed development would increase the Rate of Runoff from the developed areas of the site. To mitigate the potential increase to flood risk posed by an increased rate of runoff from the development it will be necessary to attenuate runoff and discharge to the existing surface water sewer at a controlled rate.

A Sustainable Drainage System (SuDS) solution consisting of detention basins and geocellular crate attenuation is proposed, attenuating runoff as far as is practical to be comparable to the pre-development Qbar rate of 15.1 l/s.

4.6 Surface Water Disposal

Cumbria County Council as Lead Local Flood Authority prefer design in accordance with the Cumbria Design Guide which identifies the following hierarchy of techniques to be used:

- **Prevention**: Prevention of runoff by good site design and the reduction of impermeable areas.
- **Source Control**: Dealing with water where and when it falls (e.g. permeable paving).
- **Site Control**: Management of water in the local area (e.g. swales, detention basins).
- **Regional Control**: Management of runoff from sites (e.g. balancing ponds, wetlands).

4.6.1 Consideration of SuDS Components

A full range of SuDS components and techniques have been considered for the development of the site and their applicability to the site is discussed below.

Source Control

- **Green roofs -** discounted due to cost and limits of water volume retention.
- **Soakaways** – Insufficient soil permeability.
- **Water butts** – these are suitable for the site but their effectiveness would depend on them being empty prior to a period of significant rainfall. This could occur during the summer when occupiers are likely to use the water but unlikely during the autumn and winter Irrelevant for drainage design due to their inability to provide reliable stormwater storage.
- **Permeable paving –** Insufficient soil permeability for Type A permeable block paving (full infiltration). Type B (partial infiltration) permeable block paving would be suitable for private driveways but would still require a positive drainage connection.
- **Swales –** Would require large areas within the site. On-site attenuation basin is regarded as more effective and reliable. Swales are not adopted by either the utility provider or highways authority.
- **Filter drains** – Insufficient soil permeability.
- **Infiltration trenches and basins –** Insufficient soil permeability.
- **Detention basins –** This is the preferred option to attenuate and treat the highways runoff and will provide an attractive permanent feature to the developments open space. The necessary size of an on-site detention basin has been calculated (see section 4.7.2).
- **Ponds / wetland** – A detention basin is regarded as more effective and reliable alternative.
- **Rain gardens -** discounted due to high capital and maintenance costs. Maintenance cannot practically be enforced.
- **Geocellular crate systems** – these will be required to store runoff from the individual dwellings roofs and driveways. These tanks would be wrapped and sealed with an impermeable geomembrane to provide a water-tight structure. Offsite flows would be controlled via a orifice flow control device.

4.7 Surface Water Drainage Design

The drainage design has been sized to store a future 1% AEP event of critical duration. Future climate change (40%) and urban creep (10% to housing area only) is accounted for in the design.

It is proposed to provide two separate attenuation systems to service both the highways drainage and plot drainage independently.

4.7.1 *Plot Drainage*

Individual plots and associated hardstanding will each be serviced by private geo-cellular storage systems. Silt traps will be provided upstream of each individual storage structure and discharge will

be controlled by an orifice flow control device to a rate of 0.1 l/s per plot resulting in a cumulative discharge from all 99 proposed plots of 9.9 l/s. This will enter a new offsite surface water sewer situated in Low Road that extends down the road before connecting into the existing manhole located on the culverted watercourse.

Roof water and run off from driveways will connect directly into the surface water pipe network via the proposed geocellular attenuation tanks. This will require ground levels to fall consistently around the site in order to enable a gravity connection into the drainage system.

4.7.2 *Highways Drainage*

A series of gullies will be located within the site roads to collect and discharge highways run off into a new pipe network. The highways drainage network will be directed into a detention basin. The most suitable location for a surface water detention basin is in the area to the north east corner of the site which is situated at the topographical lowpoint of the site and is naturally in an area of increased risk of ground water flooding due to the site levels. The new detention basin will be formed as a permanent feature within the public open space in this area of the site and will be designed to provide shallow, grassed slopes to provide important amenity and biodiversity benefits to the development.

An outline storage estimate has been undertaken using Source Control, which indicates that approximately 360m³ of storage will need to be provided to accommodate the highway surface water runoff within the development for a Q100 + CC (40%) design storm event.

A hydrobrake optimum vortex type flow control device will then limit discharge from the highways basin to the new offsite surface water sewer in Low Road to a rate of 5 l/s.

Therefore the combined runoff rate from the separate highway and plot drainage systems will be 14.9 l/s (9.9l/s + 5l/s = 14.9l/s) which falls within the restricted greenfield runoff Qbar rate for the development of 15.1 l/s.

Due to the site topography and proposed levels, a small section of the new highway at the entrance to the site approx. 20m in length will fall relatively steeply back towards Low Road and as such will not be able to drain via gravity into the proposed highways detention basin. It is therefore proposed that this area is drained directly via new gullies to the existing highways drainage system that serves Low Road, and approval will therefore need to be sought from Cumbria County Council.

4.7.3 *Existing Run-off from Upland Areas*

In order to mitigate against surface water and ground water flooding on the site it is proposed to incorporate a land drainage system along the western boundary of the site.

4.7.4 *Existing Culverted Watercourse*

It is recommended that the extent of the collapsed section of the existing culvert along the northern boundary within the site and adjacent to the cemetery is repaired or replaced to alleviate any surface water flooding risks in that area. Once repaired this would be the preferred means to discharge any runoff from the new land drainage system located along the western boundary. Further consultation with the LLFA is required to determine the extent of repairs required by owners outside of the proposed site boundary, and to safeguard the local area and future proof the existing culvert it is recommended that the LLFA liaise directly with the downstream Riparian owners to undertake the necessary repairs.

For further detail refer to the Drainage Layout Plans (K36110/A1/100 & 101) included in Appendix A.

4.7.5 Runoff Control

Cumulative discharge from the development shall be controlled to be comparable to the pre-development greenfield runoff Qbar rate of 15.1 l/s.

Individual plot surface water runoff will limited to 0.1 l/s via orifice flow control devices and geocellular crate attenuation tanks resulting in a cumulative flow of 9.9 l/s (0.1 l/s x 99 plots) from the proposed dwellings and associated hardstanding.

A separate system to accommodate the highways surface water runoff utilising the detention basin will limit the flow to 5 l/s via a Hydrobrake flow control device.

A Hydrobrake optimum flow control device is therefore specified with the following parameters:

Design Head = 1.300 m
Design Flow = 5.0 l/s
Orifice diameter = 101 mm
Unit Reference: MD-SHE-0101-5000-1300-5000

4.7.6 Storage Volume

The area outlined as a detention basin on the site layout plan (K36110/A1/101), would provide approx 360m³ of storage.

Additional storage in the form of geocellular crate systems is preferred to accommodate plot drainage. It is intended to utilise the areas under individual and shared private driveways where possible to locally attenuate surface water runoff from the individual plots. These crate systems will be variable in size depending on the property type and differing hardstanding areas but typically range from between approximately $5m^3$ to $10m^3$ of storage volume requirement per plot.

A surface water indicative layout (K36110/A1/101) is included in Appendix A for reference.

4.7.7 Outfall Design

A 150mm diameter outfall pipe is proposed from the detention basin/pond to the discharge point in the proposed offsite surface water drainage pipeline situated in Low Road.

4.8 Designing for Local Drainage System Failure

In accordance with the general principles discussed in CIRIA Report C635 – Designing for Exceedance in Urban Drainage [12] the proposed surface water drainage, where practical, should be designed to ensure there is no increased risk of flooding to the buildings on the site or elsewhere as a result of extreme rainfall, lack of maintenance, blockages or other causes.

4.8.1 Blockage and Exceedence

The site drainage will be designed to attenuate a 100-year design storm including a 40% allowance for climate change. The drainage system will also provide capacity for lower probability (greater design storm events) which are not critical duration. Exceedance flows shall be retained on site within the drainage system as far as practical however for storms of a greater return period it may be necessary to pass forward more flow or spill flows.

Any overland flow would either pond within the natural basin at the north east of the development or be directed towards the existing highways drainage situated in Low Road away from the properties.

In the unlikely case of blockage of the geocellular systems, associated silt traps and/or flow control chamber, spills would occur from the lowest access cover onto the new access roads. Runoff would occur along the highway and levels shall be designed such that water is constrained by kerbs and flows towards the north east corner.

The new dwellings would not be at risk of flooding due to the proposed topography of the site and careful design of the access roads / parking areas, falling away from property.

4.9 Surface Water Quality

The treatment of surface water is not a statutory requirement. Water quality remains a material consideration but there are no prescriptive standards to be imposed in terms of treatment train management. In the absence of a design standard, the SuDS Manual [9] has been used which outlines best practice.

A number of pollutants such as suspended solids, heavy metals and organic pollutants may be present in surface water runoff, the quantity and composition of the runoff is highly dependent on site use. For housing developments the pollutant load is very low.

The SuDS Manual [8] outlines best practice with regards to treatment of surface water by SuDS components prior to discharge to the environment. SuDS components can be effective in reducing the amount of pollutants within the surface water discharged and therefore environmental impact of the development. SuDS components may be installed in series to form a treatment train in order to treat the runoff.

The simple index approach as outlined in the SuDS manual has been used to assess the pollution hazard indices and proposed treatment components, the calculations are included in Appendix C. For the categories of runoff areas served by the drainage system, treatment is proposed by use of a detention pond for the site highways runoff. Table 4.5 summarises the pollution hazard and mitigation indices for this type of runoff.

Table 4.5 Pollution Hazard & Mitigation Indices- Residential Roads – Detention Basin

Indices	Suspended Solids	Metals	Hydrocarbons
Pollution Hazard	0.5	0.4	0.4
Pollution Mitigation	0.5	0.5	0.6
Treatment Suitability	**ADEQUATE**	**ADEQUATE**	**ADEQUATE**

4.10 Maintenance

Adoption of surface water drainage systems and SuDS components by the sewerage undertaker and/or the highways authority is intended wherever possible. During the detailed design stage a full review and consideration of UU requirements shall ensure the maximum practical extent of adoptable drainage in accordance with the Design and Construction Guidance for Foul and Surface Water Sewers [17] and subject to a Section 104 Agreement.

The private individual plot drainage is to be maintained by the property owners. A private management company will be responsible for maintenance of the detention basin. Highways gullies and associated pipework will be adopted by Cumbria County Council under a Section 38 Agreement. Any areas associated with social housing will be managed by the relevant social housing association.

In addition to the above measures, where applicable, a *SuDS Operations & Maintenance Plan* will be made available to the site owners detailing the requirements for future maintenance of the drainage system.

5.0 FOUL WATER DRAINAGE STRATEGY

It is proposed that foul water from the development shall be drained via gravity within the site before being connected to the existing manhole on the 150mm diameter foul sewer situated to the north east of the site within Low Road.

Under Section 106 of The Water Industry Act 1991, *'the owner / occupier of any premises shall be entitled to have his drain or sewer communicate with the public sewer of any sewerage undertaker and thereby to discharge foul water and surface water from those premises or that private sewer.'* Unless *'the making of the communication would be prejudicial to the undertaker's sewerage system'*. The drainage system shall be designed to adoptable standards to allow adoption by United Utilities under Section 104 of the Water Industry Act 1991. A pre-development enquiry has been submitted to United Utilities and their response provides an agreement in principle for a connection to the existing foul network. Correspondence is included in Appendix D.

Preliminary foul water discharge calculations have been undertaken for the whole site in accordance with the Design and Construction Guidance for Foul and Surface Water Sewers [17], see Table 5.1 below.

Table 5.1 Peak Foul Flow Rates

Sewers for Adoption 7th Edition Clause B5.1	
Peak Load based on number of dwellings, 99 No units @ 4000l/day	396,000
Total Foul Flow Rate from Site (l/s)	4.6

The estimated peak foul flow rate from the development is 4.6 litres/second.

A drainage connection via gravity to the existing 150mm foul sewer situated in Low Road is achievable, however investigations are required to determine the exact level of the foul sewer at the connection point proposed.

6.0 CONCLUSIONS AND RECOMMENDATIONS

In consideration of the Flood Risk Assessment and proposed Drainage Strategy for the site the following conclusions and recommendations are made:

- The site is located in Flood Zone 1 with an annual probability of flooding of less than 0.1% AEP (1 in 1000).
- By reference to the National Planning Policy Framework [1] on Flood Risk, More Vulnerable development is acceptable within these flood zones.
- The site is not at significant risk of flooding from surface water, groundwater, sewers, reservoirs, canals or any artificial structures.
- Surface water runoff from the site shall be positively drained and attenuated prior to discharge. The total offsite discharge rate will be less than the pre-development Greenfield Qbar rate.
- Separate highways and plot drainage systems will be required to service the development.
- Individual plot attenuation will be provided via geocellular crate systems. Upstream plot attenuation discharge will be restricted with orifice controls limiting the flow rates into the main drainage network to 0.1 l/s per plot. The cumulative flow rate from the 99 plots will total 9.9 l/s.
- A new surface water drainage network will convey the plot drainage along the site roads to the proposed connection point in Low Road at the north east corner of the site.
- A separate highway drainage system will convey highways runoff into a detention basin in the north east corner of the site. A volume of approximately 360m³ storage will be required by the basin to accommodate the highway surface water run-off.
- Discharge from the detention basin, shall be controlled to a rate of 5l/s via a HydroBrake into a new offsite surface water drainage pipe network located in Low Road which will connect into the existing system near to Jefferson Park.
- The cumulative surface water runoff rate of 14.9l/s from the two separate systems will better the existing greenfield Qbar runoff rate of 15.1 l/s.
- The foul drainage will connect via gravity into the existing 150mm foul sewer located within Low Road to the North East of the proposed development. A pre-development enquiry has provided an agreement in principle from UU.
- Full repair of the existing culvert along the northern site boundary/cemetery is recommended to prevent any risk of surface water flooding in this area.