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Drainage Strategy & Design

Proposed Residential Development, Harras Dyke Farm, Whitehaven

Washington Homes

Ref: K40340.DS/001A

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GLOSSARY OF TERMS

AEP	Annual Exceedance Probability
AOD	Above Ordnance Datum
BGL	Below Ground Level
BGS	British Geological Society
CC	Climate Change
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	RG Parkins & Partners Ltd
SFRA	Strategic Flood Risk Assessment
SuDS	Sustainable Drainage System
UU	United Utilities

1. INTRODUCTION

1.1 BACKGROUND

This report has been prepared by R. G. Parkins & Partners Ltd (RGP) for Washington Homes in support of proposals for a residential development at Harras Dyke Farm, Whitehaven, in accordance with the National Planning Policy Framework [1][2].

Copeland District Council issued planning permission for Phase 1 (4/16/2416/001) for 5 no. proposed dwellings and Phase 2 (4/16/2415/001) for 85 no. dwellings in November 2016. The following report and associated drainage layout are to discharge the following drainage related planning conditions.

- 4/16/2415/001

Condition 15 Foul and surface water drainage design

Condition 16 Surface water drainage design, SuDS Operation and Management

Condition 17 Foul water drainage design

- 4/16/2416/001

Condition 11 Foul and surface water drainage design

Condition 12 Surface water drainage design, SuDS Operation and Management

Condition 13 Foul water drainage design

The latest development proposals by Manning Elliott (drawing no. 4/21/2196/OR1) shows a combined total of 90 no. plots. The drawing can be found in Appendix A for reference.

Due to the proposed site layout, it will be necessary to serve both phases of the development via a single surface water drainage network and foul water drainage network; the Phase 1 and Phase 2 sites will thereby be referred to as ‘the site’ hereon in.

2. SITE CHARACTERISATION

2.1 SITE LOCATION

The site is located c. 1.4 m east of Whitehaven in Harras Moor on a plot of land located north of Harras Lane and west of Red Lonning. The National Grid Co-Ordinates to the centre of the site are 298845E 518430N (Figure 2.1).

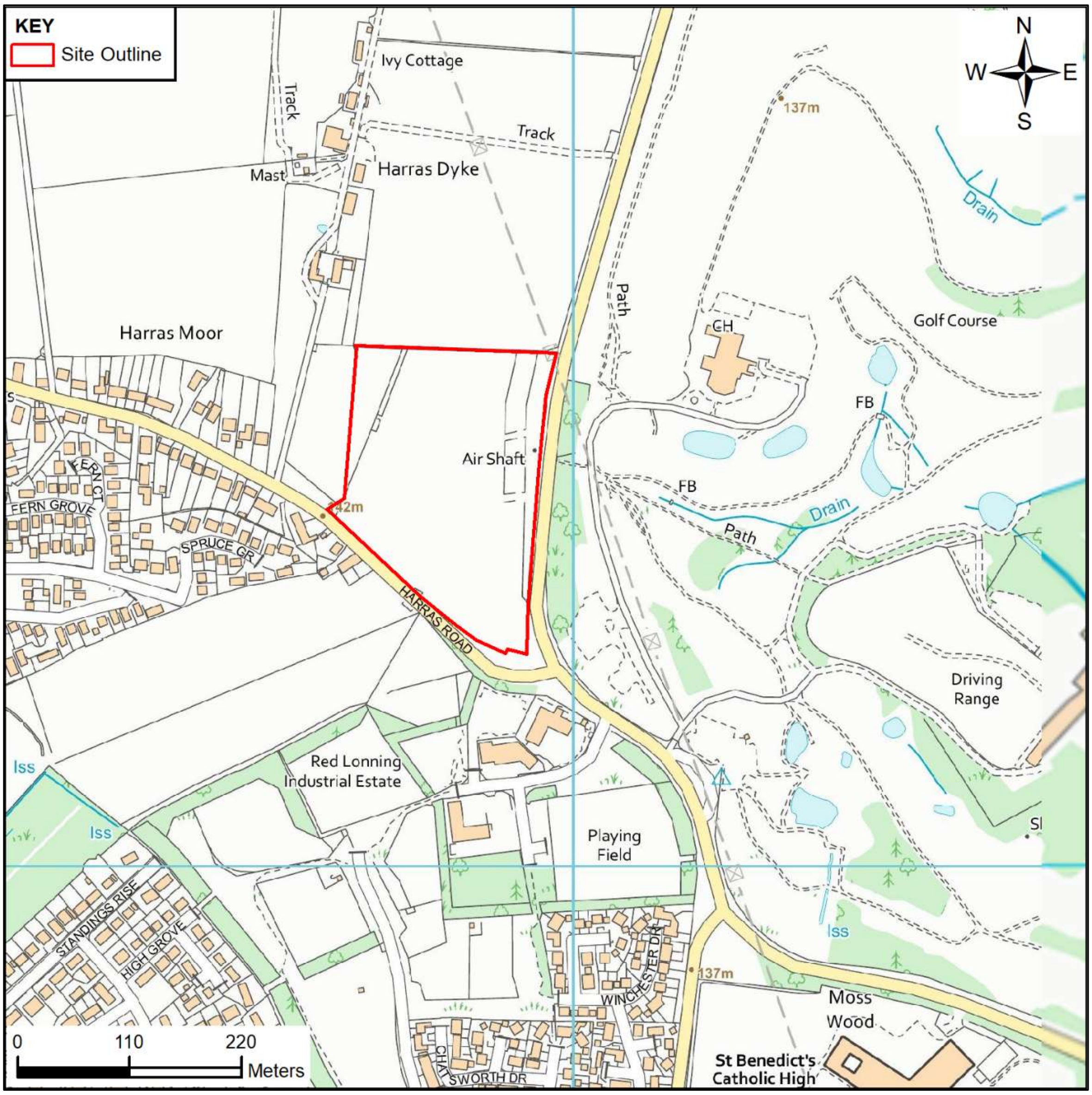


Figure 2.1 Site Location

2.2 SITE DESCRIPTION

The site covers an area of approximately 4.624 ha (46,242 m²), and at present is utilised as grazing pasture. The site is bounded to the south by Harras Road, agricultural land lies to the west with an access track serving Harras Dyke Farm further west. Red Lonning highway lies to the east with agricultural land to the north.

Topographically, the majority of the site falls from the north to the south east corner of the site, with levels ranging between ~144.400 mAOD and ~140.250 mAOD. The north west corner of the site drains to the south west corner (144.40 mAOD to 140.40 mAOD).

Access to the site is from Harras Road.

2.3 SITE HISTORY

The site has been identified that part of the site was formerly a large opencast coal mine, which has subsequently been restored.

In 1980, the site was shown as being included in the Moresby and Keekle Opencast Coal site operated by British Coal. It operated until the late 1980s.

2.4 GEOLOGY & HYDROGEOLOGY

British Geological Survey (BGS) [3] and Land Information Systems (LandIS) [4] mapping indicates the site is underlain by the geological sequences outlined in Table 2.1. The Defra Magic Maps [5] indicates the nearest Source Protection Zone is located c. 5.30 km to the south (Zone III Total Catchment).

The site is not located within a drinking water protected area or drinking water safeguard zone for surface water or groundwater.

The development site overlies a major aquifer with 'Medium-High' vulnerability.

Table 2.1 Site Geological Summary

Geological Unit	Classification	Description	Aquifer Classification
Soil	Soilscape 6	Freely draining slightly acid loamy soils	N/A
Drift	Till, Devensian	Diamicton – clay, silt, sands and gravel	Summary: Secondary (undifferentiated)
Solid (edge of site)	Whitehaven Sandstone Formation	Sandstone	Summary: Secondary A
Solid (centre of site)	Pennine Middle Coal Measures Formation	Mudstone, siltstone and sandstone	Summary: Secondary A

2.5 HYDROLOGY

Reference to OS Mapping indicates the nearest main river, Midgey Gill lies c. 830 m south of the site.

The nearest open watercourse lies 290 m to the south-east. It is culverted within a 375 mm dia. concrete pipe under the highway and golf course, at depths varying between 1.58 and 2.30 m deep. This is discussed in further detail in Section 2.6.

2.6 EXISTING SURFACE WATER DRAINAGE SYSTEMS

2.6.1 OFF-SITE CULVERTED WATERCOURSE

There is an existing culverted watercourse discharging from the south-east corner of the site. This culvert has been subject to several different CCTV surveys as listed below:

- Lanes Group PLC – April 2018 (report no. PJ293289)
- Lane Group PLC – May 2018 (report no. PJ297981)
- Lanes Group PLC – August 2023 (report no. LSO00019310)
- Atlantic Geomatics – November 2023 (utility survey and manhole inspection – drawing no. 3184-P-12 to 17)
- SK Drainage Solutions Ltd – October 2023 (report no. SK-S 161-2023)

As part of the 2023 drainage investigations the existing manholes to the culverted watercourse were renamed and are referenced hereafter and on the RGP drawings as follows:

- MHA1 => MH04
- MHA => MH03
- MHB => MH02

This culverted watercourse is designated as 'Ordinary Watercourse' downstream from MH04 and is therefore maintained by riparian ownership. Responsibility therefore lies with Cumberland Council where it runs under the public highways and the owners of the golf course where it runs through the golf course.

Surveys undertaken by Lanes Group PLC in August 2023 and SK Drainage Solutions Ltd in October 2023 confirm joint displacement within the culvert pipework between MH02 and MH03. A review of all relevant CCTV video files does not suggest the pipe condition has worsened since 2018 and it is still holding water at c. 30% of the vertical dimension.

The route and condition of the off-site culvert through the golf course was confirmed as part of the 2023 investigations and has shown that the point of discharge is an existing pond within the golf course. The final c. 46m section of culvert pipe through the golf course from MH01 to the pond outfall is 450mm diameter uPVC and is in good working condition with no issues identified.

2.6.2 ON-SITE CULVERTED WATERCOURSE & LAND DRAINAGE SYSTEM

The development site is served by a land drainage system discharging into the culverted watercourse noted above. A drawing showing the land drainage pipe layout is shown in Figure 2.2 below and was provided within a historic report by ADAS, the date of which is unknown.

The plan shows a manhole on the north-west corner (referred to hereafter as MH08) has a 225mm dia. inlet pipe from the fields to the north (extent unknown). The main carrier drain from this manhole runs in a south-westerly direction to an existing manhole (MH07). The outlet pipe from MH07 is 300mm dia. and runs in a south-easterly direction, picking up numerous lateral land drain connections before discharging into the culverted watercourse at MH04 in the south-east corner of the site.

The 2023 drainage investigations attempted to investigate and confirm the route and condition of the land drainage system from MH08 through to MH04. The 2023 Lanes Group PLC survey was able to camera c.12m downstream of MH08 (referred to as CP02) before encountering a submerged section of pipe. They surveyed upstream from MH07 (referred to as CP03) for c. 117m and encountered the same issue. The total horizontal distance measured between MH08 and MH07 is c. 129m and it can therefore be concluded that the full length of the culvert was inspected between these manholes. Downstream from MH07, they were only able to survey c. 21.4m before abandoning due to a build-up of silt in the 300mm dia. culvert pipe. The approx. horizontal distance between MH07 and MH04 is c. 305m with an approx. fall of 470mm over its length. As such the gradient of the culvert pipe is approx. 1 in 650.

In the 2023 SK Drainage survey, they were able to survey c. 78m downstream of MH08 before encountering an issue. They also surveyed the 300mm dia. culvert upstream from MH04 for a distance of 76.37m before encountering a buried manhole (ref: MH05) located somewhere within the development site boundary.

As part of the drainage proposals for the development site the main carrier land drain (between MH07 and MH04) that runs along the southern boundary next to Harras Road will be diverted at the point where it enters the western boundary of the site and will discharge into manhole MH04 in the south-east corner. This is discussed in further detail in Section 3.9.

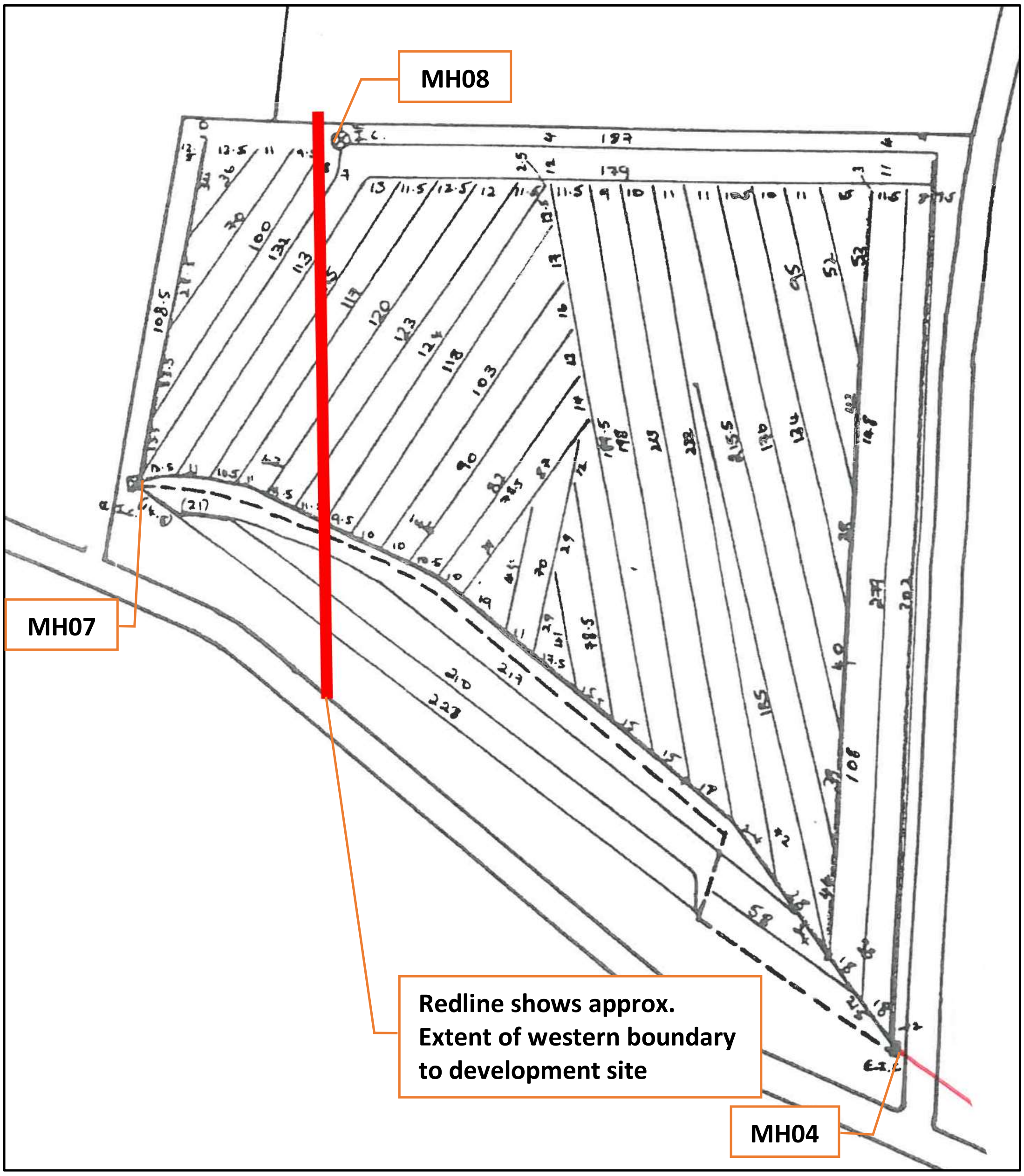


Figure 2.2 Existing Land Drainage Plan

2.7 EXISTING SEWERS

Reference to the United Utilities sewer records indicates there is a 225 mm dia. combined sewer in Harras Road. It flows in a north westerly direction serving Harras Moor. Reference to the latest development proposals indicate UU MH 7303 is located at the site entrance. According to UU records this manhole is 1.4 m deep.

The records also show the presence of a UU public 150 mm dia. foul sewer in the Red Lonning Industrial Estate. The nearest possible connecting manhole is UU MH 9003.

The CCTV drainage surveys listed above also surveyed the combined network within Harras Road along with the land drainage network. The surveys all confirmed the existing combined network is in reasonable condition and a gravity connection from the site will be possible. The foul drainage network in Red Lonning was however not surveyed.

2.8 EXISTING UTILITIES

Reference to the UU water records show there are 3 no. water mains crossing the site. There are 2 no. water mains running parallel to Harras Road within the site boundary (400 mm and 14" pipes), and a 560 mm pipe along the eastern boundary, crossing the site in the north and exiting the site in the south / south east corner. The pipes are classified as Distribution mains and trunk mains.

There are easements associated with these water mains, which are shown on RGP drawings K40340-20-25.

2.9 GROUND INVESTIGATION

There has been a significant number of Geotechnical investigations undertaken at the site in recent years due to the historical opencast mine.

The most recent intrusive ground investigations were undertaken at the site in in December 2019 by GEO Environmental Engineering Ltd[6]. GEO were commissioned to carry out soil infiltration tests to determine whether the underlying ground conditions were suitable for infiltration-based SuDS. The below information regarding ground conditions is taken from the 2019 GEO report.

Ground conditions outside the former opencast mine comprised of topsoil at varying depths between 0.20 m and 0.40 mBGL. The topsoil was described as dark grey, brown clayey sand with gravelly loam.

Made ground was encountered to depths of between c. 1.50 m and c. 1.80 mBGL, within some trial holes, all of which were located in the south-western part of the site. This is likely to be a result of opencast capping material extending beyond the highwall.

Outside of the former opencast, weathered bedrock was encountered at depths between 0.80 m and 3.20 mBGL.

The exploratory holes were typically dry except for occasional ingress from field drainage and minor seepages from the made ground at a depth of c. 1.60 mBGL.

Ground conditions within the former opencast mine comprised topsoil to depths of between c. 0.20 m and 0.46 mBGL. The topsoil was described as dark grey, brown clay.

Made ground was encountered at the base of every exploratory hole within the former opencast mine which typically comprised a cap of stiff brown slightly sandy very gravelly clay. The cap material was generally encountered to depths of between c 1.00 m and 1.90 mBGL. The material appeared very similar to the natural drift deposits encountered outside of the former opencast area and comprised reworked natural drift deposits.

Based on a review of mine abandonment plans show the deepest area of coal appears to have been extracted at c. 96.00 mAOD. Therefore, based on current topographic survey data, the opencast backfill may be up to 48m.

Bedrock was not encountered within the former opencast area during the ground investigation.

The report concluded that the site is underlain by glacial till overlying solid strata of the Middle Coal Measures Formation. The report also identified coal seams that are conjectured as potentially sub cropping on site.

The report identified a potential for shallow unrecorded mine workings beneath areas of the site which have not been excavated during the opencast coal mining operations on site.

For further details refer to Geo Environmental Engineering Report No. GEO2022-5231.

Sirius have subsequently been appointed to undertake additional work at the site, that will review the key geotechnical constraints at the site, including foundation design, settlements (total and differential) and highway location and profile related to the former site use as an opencast mine.

Possible additional works include inundation settlement testing, along with the consideration of the opencast highwall profile and geometry. The assumed highwall location is shown on the RGP drainage layout plan included in Appendix A for reference.

2.10 COAL MINING

The Coal Authority Coal Mining Report indicated that the site is within the likely zone of influence of workings in two seams of coal at depths of between 130 mBGL and 200 mBGL, with the latest date of workings being 1961. The report states that these workings are not considered to pose a significant risk to the proposed development site [9].

The report also identified a former mine shaft in the eastern part of the site which is also identified on historical and current map extracts. A concrete marker post was identified in this location near the eastern boundary.

Due to the former opencast mine, the report noted a potential for deep and extensive made ground on site. The report also indicated a low risk of ground contamination and a very low risk of ground gas due to the site history and the potential for significant made ground. The risk to the controlled waters and surrounding land was considered negligible as significant contamination sources were not encountered.

3. SURFACE WATER DRAINAGE STRATEGY & DESIGN

3.1 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 [10]
- Code of Practice for Surface Water Management, BS8582:2013, November 2013[11]
- Rainfall Runoff Management for Developments, Defra/EA, SC030219, October 2013[12]
- Designing for Exceedance in Urban Drainage – Good Practice, CIRIA Report C635, 2006[13]
- Flood Estimation Handbook (FEH)[14]
- Flood Studies Report (FSR), Volume 1, Hydrological Studies, 1993[15]
- Flood Studies Supplementary Report No 14 (FSSR14), Review of Regional Growth Curves, 1983[16]
- Flood Estimation for Small Catchments, Marshall & Bayliss, Institute of Hydrology, Report No. 124 (IoH 124), 1994[17]

The following drainage strategy is based on the latest site layout plan by Manning Elliott Partnership (drawing no. 4/21/2196/OR1), which is included in Appendix A for reference. Any alterations to the site plan resulting in changes to impermeable areas will require the drainage strategy to be revisited.

3.2 PRE-DEVELOPMENT RUNOFF ASSESSMENT

As the site covers an area of less than 200 ha the Greenfield calculations have been undertaken in accordance with methodology described in IoH 124[17]. For catchments of less than 50 ha the Greenfield runoff rate is scaled according to the size of the catchment in relation to a 50-hectare site. The calculation has been based on the entire site area of 4.624 ha.

Full details of the calculations and the methodology for deriving the Peak Rate of Runoff are in included in Appendix B, and a summary included in Table 3.1.

Table 3.1 Pre-Development Greenfield Runoff Rates

Rate of Runoff (l/s)	
Event	**Greenfield**
Q1	33.5
QBAR	38.4
Q10	53.1
Q30	65.4
Q100	80.0
Q100 + 50% CC	120.0

3.3 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 3.2 shows the measured proposed land cover areas. The highest percentage is garden and landscaped areas at 53%, access road and footways at 20%, roof areas at 14%, parking and paved areas at 7%, and basin / swale areas at 5%.

Table 3.2 Land Cover Areas

Land Cover	Area		Percentage of total site area
	m^2	Ha	
Total Roof Area	6607	0.661	14%
Basin Area	2250	0.225	5%
Total Access Road & Footway	9464	0.946	20%
Total Parking & Paved Area	3370	0.337	7%
Gardens & Landscaped Areas	24550	2.445	53%

To develop the detailed drainage design, only certain surfaces and areas will be positively drained into the surface water network. Positively drained areas include roof areas, car parking, access road and footways. All other areas (principally gardens, landscaping and patios) will either have a permeable surface or will have no positive drainage (i.e. patios will run-off to landscaped or garden areas). Table 3.3 summarises this and shows that positively drained areas will cover 53% of the site and permeable areas 47%.

Table 3.3 Summary of drained and undrained areas into surface water drainage system

Land Cover	Area		Percentage of total site area
	m^2	Ha	
Total Positively Drained Area	21690	2.169	47%
Remaining Undrained Area	24550	2.455	53%

3.4 RUNOFF CONTRIBUTION FROM PERMEABLE AREAS

A 40% contribution from pervious / permeable areas should be allowed for within the calculations. Guidance by HR Wallingford stipulates 30% is the proposed default factor, the inclusion of this uplift will result in highly conservative design.

3.5 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:

3.5.1 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.

The EA have provided a peak rainfall online map showing the anticipated changes in peak rainfall intensity across the UK. Climate change allowances are now provided on a catchment-by-catchment basis. The site falls within the South West Lakes catchment. Table 3.4 outlines the EA guidance for this catchment, for the anticipated design life of the proposed development.

In line with current guidance and for conservative design, a 50% allowance shall be used within this assessment.

Table 3.4 South West Lakes Management Catchment Peak Rainfall Allowances (1.0 AEP)

South West Lakes (1.0%AEP)	Central Allowance (%)	Upper End Allowance (%)
2050s	30	45
2070s	35	50

3.5.2 URBAN CREEP

BS 8582:2013[11] outlines best practice regarding 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 has been applied to the contributing area used for surface water drainage design.

3.5.3 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.

3.5.4 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 and are used for design.

3.5.5 RAINFALL MODEL

The calculations use the REFH2 unit hydrograph methodology in line with best practice as outlined in the SuDS Manual[10]. The calculations use the most up to date available catchment descriptors (2022) provided by the Centre for Ecology and Hydrology Flood Estimation Handbook web service.

3.6 LLFA CORRESPONDENCE

RGP held a meeting with LLFA Highways officers from Cumberland Council in September 2023 to discuss proposals for the site. It was agreed during this meeting that:

- The site is served by an existing land drainage / culvert system. The offsite culvert is a 375 mm dia. pipe that runs under the highway and into the golf course, prior to discharge into an existing surface water feature.

- There is a section of this culvert within the public highway that has settled (See section 2.6.1).

- There have been some recorded flooding issues with the section of land drain/culvert that runs through the neighbouring parcel of land to the west. Recent CCTV survey was abandoned due to silt build up. The main carrier land drain is to be retained/diverted/remediated as part of the development proposals, thereby retaining the existing flows from the north. All existing lateral land drains within the development site will be removed as part of the proposals. No development run-off will discharge directly into the existing land drainage network.

- Infiltration-based SuDS is not suitable due to the risk of inundation settlement of the Made Ground within the infilled opencast mine. Elsewhere the underlying ground conditions are not suitable for infiltration-based SuDS. The proposed drainage strategy will therefore comprise a combination of attenuation-based SuDS. These will include below ground over-sized pipes and above ground features, primarily a single SuDS detention basin located in the south-east corner of the site. The size and extent of the basin will be constrained by existing UU water pipes and associated 10m wide easements. Consideration of other SuDS components, such as swales, filter drains and gravel margins to be considered as part of the drainage strategy. The SuDS detention basin will provide the principal form of treatment. The intention is to get both the surface and foul water sewers adopted under a S104 Agreement, either with UU or a NAV.

- It was agreed that the Greenfield run off rate for the whole site (38.4 l/s) would be acceptable, due to the extensive land drainage network currently serving the site. It was also agreed a 40% contribution from pervious / permeable areas should be allowed for. Guidance by HR Wallingford stipulates 30% is the proposed default factor, the inclusion of this uplift will result in highly conservative design.

3.7 SURFACE WATER DISPOSAL

Surface water disposal has been considered in line with the hierarchy outlined in the SuDS Manual[10]. The approach considers infiltration drainage in preference to disposal to watercourse, in preference to discharge to sewer.

Infiltration testing undertaken at the site by GEO Environmental Engineering confirmed that the ground is not suitably permeable to facilitate soakaway drainage. For further information refer to Section 2.6. The site was also formerly an open cast mine, and as such an infiltration drainage strategy is not considered appropriate.

The site naturally falls towards an existing low point in the south-east corner of the site, where there is a connecting manhole to the culverted ordinary watercourse within Harras Road. As part of the strategy, this manhole will be retained, connecting the new surface water drainage system to the existing culvert.

3.8 SURFACE WATER DRAINAGE DESIGN

The proposed surface water drainage network serving the entire developable area of the site has been modelled using Causeway Flow (results are included in Appendix B).

The drainage design has been sized to store a future 1% AEP event of critical duration without any flooding. Future climate change (50%) and urban creep (10% to housing roof areas only) and 40% uplift for green spaces is accounted for within the calculations.

It is proposed that all impermeable site areas i.e. roof, driveway and road areas will ultimately drain via. gravity through a network of pipes and chambers into a shared detention basin located in the natural respective low point of the site.

The new detention basin will be formed as a permanent feature in an area designated as open space and will be designed to incorporate shallow, grassed slopes (1:3 gradient) to provide important amenity and biodiversity benefits to the development. The basin will provide 967 m^3 of attenuation.

A flow control chamber incorporating a Hydrobrake will be located downstream of the detention basin restricting discharge to the greenfield runoff rate (QBAR) of 38.4 l/s, prior to discharge into the existing culverted watercourse within Harras Road, via an existing connection.

Additional storage will be provided upstream of the detention basin, and this will be in the form of a series of conveyance swales / shallow basins in sequence, with interconnecting pipework, along the site’s eastern boundary. Flow controls and a 150 dia. pipe will be used to throttle the flow within the conveyance swales, allowing the storage features to be utilised to their maximum capacity. The swales will provide a total of 985 m^3 of storage.

In the west of the site, additional attenuation volume will be provided within a series of oversized pipes within a manifold arrangement (3 no. pipes at 1800 dia.), providing 420 m^3 of storage. This will discharge into the surface water network within the access road, upstream of the detention basin.

The access road and car parking areas will be constructed using conventional surfacing in the form of asphalt. The access road will be drained via. a series of highway gullies into the proposed surface water drainage network.

Due to the sites former use, it is proposed that all pipe work will be laid in geogrid mechanically stabilised pipe bedding, installed on top of a ground improvement solution to limit differential settlement. This ground improvement solution will be designed and specified by the geotechnical specialists, Sirius.

Full details of the drainage proposals are included on RGP drawings K40340-20-25, included in Appendix A.

3.9 DIVERSION WORKS TO EXISTING ON-SITE CULVERTED WATERCOURSE

As described in Section 2.6.2 there is an existing land drainage system running through the development site and discharging to a culverted watercourse leading off-site. The existing drainage system serves not only the site itself but also conveys run-off from the fields to the north. It will therefore be necessary to ensure that the existing drainage system is modified during the construction phase to ensure upstream run-off entering site from the north via MH08 continues to discharge via MH04, located in the south-east corner of the site.

It is proposed that the existing 225mm land drain/culverted watercourse between MH08 and MH07 is diverted down the western site boundary via a new manhole and 225mm dia. pipe. This will ensure that existing structural/capacity issues as identified in the CCTV survey (Section 2.6.2) are mitigated. The existing 225mm pipe beyond this point will be left in-situ as existing to retain any existing lateral land drain connections.

It is proposed that the existing 300mm dia. culvert pipe between MH07 and MH04 is diverted/replaced where it enters the development site on the western boundary. A new manhole will be constructed at this point and will also provide a point of connection for the new 225mm pipe running down this western boundary. The exact position/depth of the existing culvert pipe will be confirmed via trial pit investigation and a detailed drainage diversion design will be undertaken. A new 300mm dia. pipe will be installed and will be routed south and south-east, to the front of Plots 71 – 81 before re-connecting into the existing culvert pipe near the front of Plot 74. All existing lateral land drainage pipes within the development site will become redundant and will be removed as part of the development proposals.

The proposed diverted land drain/culverted watercourse is shown on the RGP drawings included in Appendix A.

3.10 OTHER BENEFITS OF DEVELOPMENT

The development site in its current agricultural form is sparse grazing pasture on sloping land, underlain by relatively impermeable soil, provides little in the way of natural flood defence or attenuation to overland flows and stormwater runoff. The land in its current form also lacks any meaningful biodiversity or amenity value and provides limited benefits to the surrounding community.

The proposed development site will tie into the existing topography via careful design. Slopes, gardens and open space areas will be carefully landscaped using a variety of plants, shrubs and trees, providing a net gain in biodiversity and enhanced storage/protection against overland flows.

As such the existing hydraulic regime of the site will be modified whereby overland and subsurface flows will be intercepted, attenuated, and re-directed by below ground structures, positive drainage and service trenches.

Hydraulic gradients and velocities will be reduced, and the risk of downstream flooding would not be increased. Any surface emergence of any groundwater on-site will be intercepted by land drainage systems and directed away from existing dwellings.

3.11 DESIGNING FOR LOCAL DRAINAGE SYSTEM FAILURE

In accordance with the general principles discussed in CIRIA Report C635 – Designing for Exceedance in Urban Drainage [13] the proposed surface water drainage, where practical, should be designed to ensure there is no increased risk of flooding to the proposed dwellings on the site or elsewhere as a result of extreme rainfall, lack of maintenance, blockages or other causes. These measures are discussed below.

3.11.1 BLOCKAGE & EXCEEDANCE

The sustainable drainage system has been designed to attenuate a 100-year design storm including a 50% allowance for climate change, with no flooding. The drainage system will also provide capacity for lower probability (greater design storm events) which are not critical duration.

The crest level of the detention basin will be locally lowered by 100mm to create a spillway for any exceedance flows and these will be channelled into the green area in the south west corner of the site. This area is set lower than the neighbouring highway (Harras Road) and should not increase flood risk downstream.

Should flooding occur within any of the flow control devices, manholes or silt traps, exceedance flows would follow the road gradients, entering the network via the highway gullies. Any further exceedance flows will follow the topographic gradients and discharge into the detention basin in the south east corner of the site, where the flow control will restrict flows to the Greenfield Qbar.

3.11.2 SURFACE STORAGE & EXTERNAL LEVELS

The site levels have been designed to offer additional surface water storage volume and conveyance of flood water should the SuDS and drainage system fail, flood or exceed capacity. Where appropriate, the kerb lines have been raised to channel surface water runoff back into the drainage system or onto the existing highway.

3.11.3 BUILDING LAYOUT & DETAIL

The finished floor levels to the new dwellings have been designed and situated to ensure that they are not at risk of flooding from overland flow. Finished floor levels have been set 150mm above external paved areas (whilst providing level access where needed). External footpaths typically fall away from the thresholds, ensuring that any flood water runs away from, rather than towards the dwellings.

3.12 SURFACE WATER TREATMENT

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 has been used which outlines best practice.

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 upon site use. For housing developments, the pollutant load is very low. The SuDS Manual[10] 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 to treat the runoff.

For the three categories of runoff areas served by the drainage system, roof areas, residential parking and residential roads, treatment is proposed by directing all surface water runoff via. a final detention basin before discharge off site. Tables 3.5 -3.7 summarise the pollution hazard and mitigation indices for this type of runoff and show that adequate treatment of surface water runoff is provided by the use of the detention basin.

This approach is however highly conservative, as additional treatment will be provided for the areas of roofs, driveways and access roads, also served by the conveyance swales prior to discharge into the basin. The below calculations therefore present a worst-case scenario in terms of treatment, and it is concluded sufficient treatment is provided across the site. Table 3.8 shows the levels of treatment provided for those areas of highway served by both swale and detention basin, for completeness.

A silt trap will also be located upstream of the detention basin to capture and solids before discharge into this storage feature.

Table 3.5 Pollution Hazard & Mitigation Indices - Roof Areas

Indices	Suspended Solids	Metals	Hydrocarbons
Pollution Hazard	0.20	0.20	0.05
Pollution Mitigation	0.50	0.50	0.60
Treatment Suitability	**Adequate**	**Adequate**	**Adequate**

Table 3.6 Pollution Hazard & Mitigation Indices - Parking Areas

Indices	Suspended Solids	Metals	Hydrocarbons
Pollution Hazard	0.50	0.40	0.40
Pollution Mitigation	0.50	0.50	0.60
Treatment Suitability	**Adequate**	**Adequate**	**Adequate**

Table 3.7 Pollution Hazard & Mitigation Indices - Road Areas

Indices	Suspended Solids	Metals	Hydrocarbons
Pollution Hazard	0.50	0.40	0.40
Pollution Mitigation	0.50	0.50	0.60
Treatment Suitability	**Adequate**	**Adequate**	**Adequate**

Table 3.8 Pollution Hazard & Mitigation Indices - Road Areas Swale & Detention Basin

Indices	Suspended Solids	Metals	Hydrocarbons
Pollution Hazard	0.50	0.40	0.40
Pollution Mitigation	0.75	0.85	0.90
Treatment Suitability	**Adequate**	**Adequate**	**Adequate**

3.13 OPERATIONS & MAINTENANCE RESPONSIBILITY

All underground pipework will be offered for adoption under a S104 Agreement with UU or a NAV. This pipework will include oversized pipes, up to the headwalls of the basins and swales and the flow control devices. All interconnecting pipework between the swales will also be offered for adoption.

It is proposed the detention basin and swales will be privately maintained by a third-party management company. An '*Operations & Maintenance Plan'* (K40340.OM/002) has been prepared by RGP detailing the requirements for future maintenance of the drainage system.

The on-site diverted culverted watercourse will be covered under riparian ownership.

4. FOUL WATER DRAINAGE STRATEGY

It is proposed that foul water from the new development shall be drained via gravity within the site. Due to the topography, there will be a requirements for 2 no. connections into the UU public foul network. The north and eastern portion of the site (33 no. plots) will discharge to UU MH 7303 in Harras Road, with the remaining 57 no. plots discharging into UU MH 9003. UU MH9003 lies within the Red Lonning industrial estate, it will therefore be necessary to lay a 150 dia. pipe within the highway (Harras Road), across a highways verge and into the industrial estate to enable a gravity connection.

A number of CCTV drainage surveys, and a review of the detailed UU sewer records have confirmed that the sewers are sufficiently deep to enable conventional gravity connections.

The new connections will be subject to formal application to UU under S106 agreements. Foul water discharge calculations have been undertaken for the 90 no. dwelling, and subdivided into their respective discharge points, in accordance with the Design and Construction Guidance for Foul and Surface Water Sewers [20], as shown in Table 4.1.

A pre development enquiry has been submitted to UU, who have confirmed the proposed foul connections are acceptable in principle. Full correspondence can be found in Appendix C.

Table 4.1 Peak Foul Flow Rates

Sewerage Sector Design & Construction Guidance Clause B3.1	
Total Peak Load based on Number of Dwellings, 90 no. units @ 4000 l/day	360,000
Peak Flow Rate from Site (l/s)	4.17
Peak Flow Rate into UU MH 7303 (33 no. plots)	1.53
Peak Flow Rate into UU MH 9003 (57 no. plots)	2.64

The estimated total peak foul flow rate for the development is 4.17 lit/sec. For further details, refer to the Drainage Layout Plan included in Appendix A (K40340-20).

5. CONCLUSIONS AND RECOMMENDATIONS

The proposed Drainage Strategy can be summarised as follows:

- The site was previously in use as an opencast mine but has subsequently been infilled and compacted. The only remnants on site of its previous history are a former mine shaft, marked with a concrete marker post in the east of the site.

- Ground investigation undertaken on December 2019 by GEO Environmental Engineering Ltd concluded that the site is not suitable for infiltration-based SuDS drainage and an off-site surface water drainage solution is required.

- It is proposed that surface water runoff from the site will be attenuated within a combination of SuDS features, ranging from a manifold oversized pipe arrangement, oversized pipes, conveyance swales and a detention basin, thereby providing ~2370m^3 of storage within the site.

- A flow control chamber incorporating a Hydrobrake will be located downstream of the detention basin restricting discharge to the greenfield development QBAR runoff rate of 38.4 lit/sec.

- The drainage has been designed to attenuate a Q100 + 50% climate change design event, with an uplift of 10% on roof areas for urban creep, and a 40% uplift in pervious areas, resulting in a highly conservative drainage design, as per discussions with the LLFA.

- The access road and driveways will be constructed using conventional surfacing in the form of asphalt and block paving respectively. The access road will drain via. highway gullies and covey flows towards the detention basin and swales.

- Attenuated discharge from the site shall be to the existing culverted ordinary watercourse, utilising a connecting manhole on site. The culvert crosses under Harras Road and Red Lonning before discharging to a surface water feature within the golf course, east of the site. This culverted watercourse is under riparian ownership, so will be maintained by Cumberland Council Highways and the owners of the golf course.

- The drainage solution proposes to limit all post-development flows to the pre-development QBAR (i.e. max. 38.4 lit/sec) and as such this will provide a significant reduction of flow into the culvert when compared to the pre-development Greenfield run-off rates for the Q10, Q30 & Q100 storm events. It can therefore be concluded that the development will not adversely affect downstream flood risk and that the on-site storage and attenuation will help to reduce downstream flood risk. As such, there is no requirement for Thomas Armstrong to undertake any repairs to the displaced section of culverted watercourse below Red Lonning.

- Due to the sites former use, it is proposed that all pipe work will be laid in geogrid mechanically stabilised pipe bedding, installed on top of a ground improvement solution. This solution will be designed by geotechnical specialists, Sirius.

- Treatment of surface water is proposed by the detention basin and conveyance swales.

- It is proposed foul water drainage shall discharge via gravity connections into the existing public 150 mm dia. foul water sewers. Due to the topography of the site, and to enable a gravity connection for all dwellings, 33 no. dwellings will discharge into UUMH 7303. The peak flow rate for these plots is 1.53 l/s. The remaining 57 no. plots will discharge into UU MH 9003 in Red Lonning industrial estate south of the site, at a peak flow rate of 2.64 l/s.

- A pre development enquiry has been submitted to UU, who have confirmed the foul connection points are acceptable in principle.

6. REFERENCES

[1] Ministry of Housing, Communities and Local Government, National Planning Policy Framework, December 2023.

[2] Ministry of Housing, Communities and Local Government, Planning Practice Guidance to the National Planning Policy Framework, August 2023

[3] British Geological Survey, April 2024 Geoindex.

http://mapapps2.bgs.ac.uk/geoindex/home.html

[4] Land Information System (LANDIS)- Soilscapes viewer, April 2024 *http://www.landis.org.uk/soilscapes*

[5] Defra Magic Maps, 2024

https://magic.defra.gov.uk/MagicMap.aspx.

[6] Lanes Group Plc, Thomas Armstong Limited, Whitehaven PJ293289, April 2018

[7] Lanes group Plc, Thomas Armstong Limited, Harras Moor, Whitehaven PJ297981, May 2018

[8] GEO Environmental Engineering Ltd, December 2019. Phase II: Ground Investigation Report Proposed Residential Development of Land at Harras Dyke Farm, Harras Moor, Whitehaven. Cumbria. Report no. 2019-3889.

[9] Elliott Environmental Surveyors, Coal Mining Risk Assessment Report for land at Harras Moor, Whitehaven, Cumbria, Report No. EES16-199, December 2016

[10] CIRIA, The SuDS Manual, Report C753, 2015.

[11] BS8582:2013, Code of Practice for Surface Water Management, November 2013.

[12] DEFRA/EA, Rainfall Runoff Management for Developments, SC030219, October 2013.

[13] CIRIA, Designing for Exceedance in Urban Drainage – Good Practice, Report C635, London, 2006.

[14] Centre for Ecology and Hydrology, Flood Estimation Handbook, Vols. 1 – 5 & FEH CD-ROM 3, 2009.

[15] Institute of Hydrology, Flood Studies Report, Volume 1, Hydrological Studies, 1993.

[16] Institute of Hydrology, Flood Studies Supplementary Report No 14 – Review of Regional Growth Curves, August 1983.

[17] Marshall & Bayliss, 1994. Flood Estimation for Small Catchments, Report No. 124 (IoH 124), Institute of Hydrology.

[18] Department for Environment, Food and Rural Affairs, Non-Statutory Technical Standards for Sustainable Drainage Systems, March 2015

[19] Innovyze, 2022, Micro Drainage Source Control

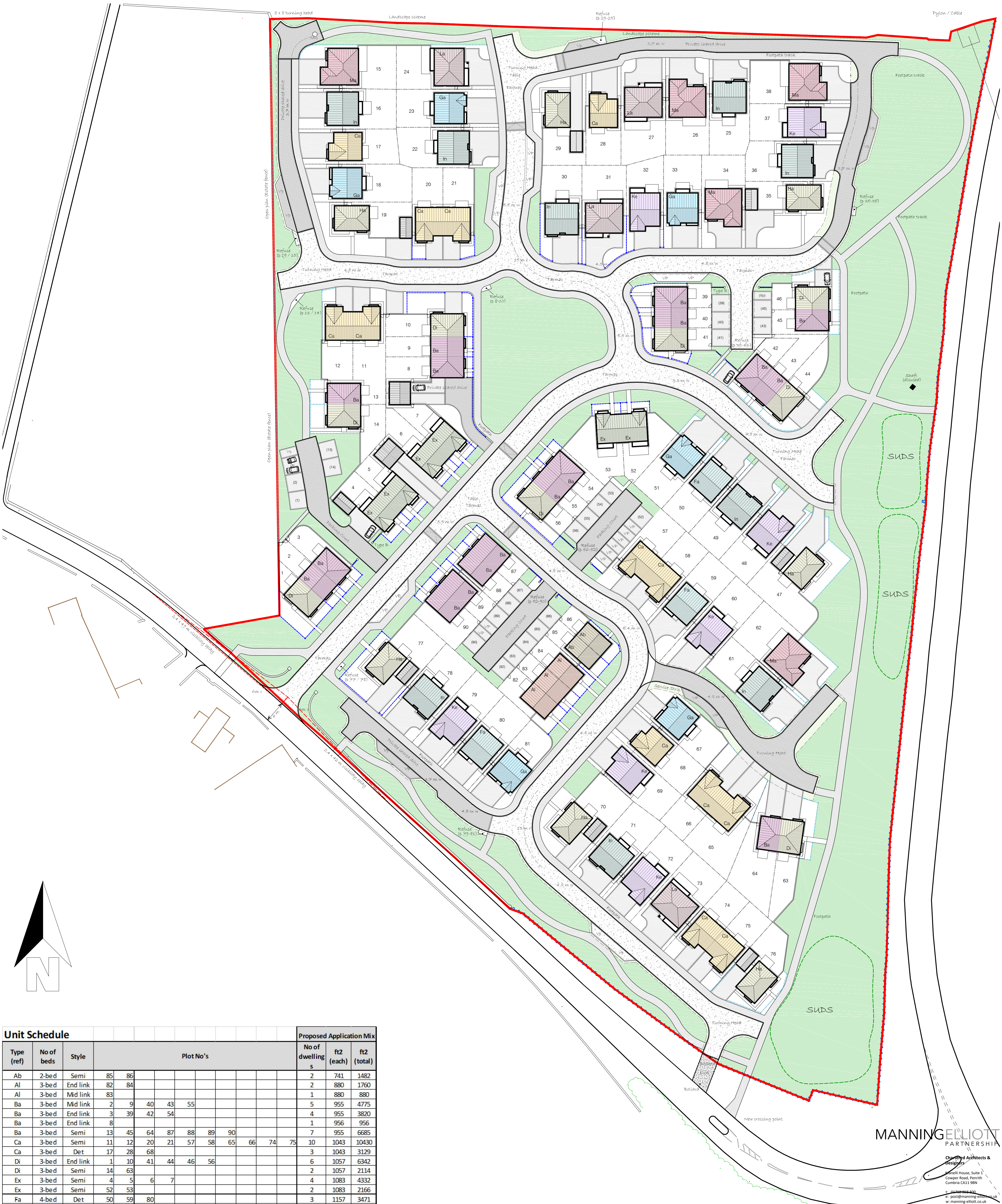
[20] Water UK, Design and Construction Guidance for Foul & Surface Water Sewers Offered for Adoption Under the Code for Adoption Agreements for Water and Sewage Companies Operating Wholly or Mainly in England, Approved Version 10, October 2019

APPENDIX A

DRAWINGS

REVISIONS:

E. Highways & Footways consultation update. 26/05/22



Unit Schedule

Type (ref)	No of beds	Style	Plot No's										No of dwellings	ft2 (each)	ft2 (total)
Ab	2-bed	Semi	85	86									2	741	1482
Al	3-bed	End link	82	84									2	880	1760
Al	3-bed	Mid link	83										1	880	880
Ba	3-bed	Mid link	2	9	40	43	55						5	955	4775
Ba	3-bed	End link	3	39	42	54							4	955	3820
Ba	3-bed	End link	8										1	956	956
Ba	3-bed	Semi	13	45	64	87	88	89	90				7	955	6685
Ca	3-bed	Semi	11	12	20	21	57	58	65	66	74	75	10	1043	10430
Ca	3-bed	Det	17	28	68								3	1043	3129
Di	3-bed	End link	1	10	41	44	46	56					6	1057	6342
Di	3-bed	Semi	14	63									2	1057	2114
Ex	3-bed	Semi	4	5	6	7							4	1083	4332
Ex	3-bed	Semi	52	53									2	1083	2166
Fa	4-bed	Det	50	59	80								3	1157	3471
Ga	4-bed	Det	18	23	33	51	67	81					6	1200	7200
Ha	4-bed	Det	19	29	35	47	70	76	77				7	1199	8393
In	4-bed	Det	16	22	25	30	36	49	61	71	78		9	1335	12015
Ke	4-bed	Det	32	37	48	60	69	72	79				7	1425	9975
La	4-bed	Det	24	27	31	73							4	1506	6024
Ma	5-bed	Det	15	26	34	38	62						5	1589	7945
													90		**103894**

Proposed Application Mix

	Mid lir	End Lir	Semi	Det	TOTAL
2-bed			2		**2**
3-bed	6	13	25	3	**47**
4-bed				36	**36**
5-bed				5	**5**
	6	**13**	**27**	**44**	**90**

0 10 20 50 100

MANNINGELLIOTT PARTNERSHIP

Chartered Architects & Designers

Manelli House, Suite 1
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e: post@manning-elliott.co.uk
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project title:
Proposed Housing Development
Land at Harras Dyke Farm
Whitehaven

drawing title:
Site Layout Plan as Proposed

issue stage:
PLANNING ISSUE

date: APR 21 | drawn: MH/CS | scale @ A1: 1:500

drawing number: 1931-PL210 | revision: E

Rev	Description	Date	Revised by	Checked by	Approved
B	Plot drainage added & main drainage updated following comments from UU	26/07/24	TM	TM	TM
A	Minor amendments	07/05/24	TM	TM	TM

Issue Purpose: **Planning**

Do not scale from this drawing

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Kendal | 01539 729393 Lancaster | 01524 32548

Client: Washington Homes

Project: Harras Dyke Farm, Whitehaven

Drawing Title: Foul and Surface Water Drainage Plan (Full Site)

Scale @ A1: 1:500	First Issue: 26/04/24	Office of Origin: Kendal
Drawn by: SR	Checked by: RH	Approved: TM
Project No: K40340	Drawing No: 20	Rev: B
BIM No:		

APPENDIX B

CALCULATIONS

R G PARKINS 97 King Street | Lancaster | LA1 1RH Tel:01524 32548 Email: office@rgparkinslancaster.co.uk	**Wallingford Runoff Estimation**	Job Number K40340	Page Number 1 of 6
		Calc by RH	Check by
	Harras Road Whitehaven	Date 24/04/2024	Revised -

DESIGN BASIS MEMORANDUM - PEAK RATE OF RUN-OFF CALCULATION

Design Brief

The following peak rate of run-off calculations have been undertaken to determine changes in peak flow resulting from the development of a greenfield or brownfield site. These calculations are for the **Peak Rate of Run-Off** requirements only.

Background Information & References

The site area **is less than** 200ha and the Greenfield (pre-development) calculation has been undertaken in accordance with methodology described by Marshall & Bayliss, Institute of Hydrology, Report No. 124, Flood Estimation for Small Catchments, 1994 (IoH 124).

In addition, the following references have been used in the preparation of these calculations:

- Interim Code of Practice for Sustainable Drainage Systems (SUDS), CIRIA, 2004
- CIRIA, The SUDS Manual, Report C753, 2015
- Designing for Exceedance in Urban Drainage - good practice, CIRIA Report C635, 2006
- Flood Estimation Handbook (FEH)
- Flood Studies Report (FSR), Volume 1, Hydrological Studies, 1993
- Flood Studies Supplementary Report No 2 (FSSR2), The Estimation of Low Return Period Floods
- Flood Studies Supplementary Report No 14 (FSSR14), Review of Regional Growth Curves, 1983
- Planning Practice guidance of the National Planning Policy Framework, Recommended national precautionary sensitivity ranges for peak rainfall intensities, peak river flows, offshore wind speeds and wave heights.

Proposed Land Use Changes

Changes to the existing site are as follows:

Brownfield Site to Brownfield Site (Reduced Impermeable Area)

Results Summary

Rate of Run-Off (l/s)			
Event	**Greenfield**	**Pre-Development Brownfield**	**Post-Development**
Q1	33.5	182.1	182.1
QBAR	38.4	266.6	266.6
Q10	53.1	364.2	364.2
Q30	65.4	444.8	444.8
Q100	80.0	570.2	570.2
Q100 + 50% CC	120.0	855.3	855.3

SITE AREAS (LAND COVER AREAS)

Existing Impermeable & Permeable Land Cover

Total Site Area: **4.6242** ha **46242** m²

Existing Impermeable & Permeable Land Cover

Land Cover	Area (m²)	Area (ha)	Percentage of total site area
Total impermeable area	46242.0	4.624	100%
Remaining permeable area	0.0	0.000	0%

Proposed Land Cover Areas

Land Cover	Area (m²)	Area (ha)	Percentage of total site area
Total roof area	6607.0	0.661	14%
Basin Area	2250.0	0.225	5%
Total Highway	9464.0	0.946	20%
Total parking and paved area	3370.0	0.337	7%
Garden & landscaped areas	24551.0	2.455	53%

Proposed Impermeable & Permeable Land Cover

Land Cover	Area (m²)	Area (ha)	Percentage of total site area
Total impermeable area	21691.0	2.169	47%
Remaining permeable area	24551.0	2.455	53%

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Wallingford Runoff Estimation	Job Number: K40340	Page Number: 3 of 6
	Calc by: RH	Check by: 0
Harras Road Whitehaven	Date: 24/04/2024	Revised: -

ESTIMATION OF QBAR (RURAL) (GREENFIELD RUNOFF RATE)

IoH 124 based on research on small catchments < 25 km2

Method is based on regression analysis of response times
using catchments from 0.9 to 22.9 km^2

$QBAR_{rural}$ is mean annual flood on rural catchment
$QBAR_{rural}$ depends on SOIL, SAAR and AREA most significantly

$$QBAR_{rural} = 0.00108 \times AREA^{0.89} \times SAAR^{1.17} \times SOIL^{2.17}$$

For SOIL refer to FSR Vol 1, Section 4.2.3 and 4.2.6 and IoH 124

Contributing watershed area

Area, A	=	500000	m^2	insert 50 ha for EA
	=	0.500	km^2	small catchment method
	=	50.000	ha	
SAAR	=	**1114**	mm	From FEH Web Service (point data)

Soil index based on soil type, SOIL

$$= \frac{(0.1S1+0.3S2+0.37S3+0.47S4+0.53S5)}{(S1+S2+S3+S4+S5)}$$

Where:	S1	=		%
	S2	=		%
	S3	=		%
	S4	=	**100**	%
	S5	=		%
			100	%
So,	SOIL	=	**0.47**	

Note: for very small catchments it is far better to rely on local site investigation information.

$QBAR_{rural}$	=	0.416	m^3/s
	=	415.7	l/s

Small rural catchments less than 50 ha
The Environment Agency recommends that this method should be used for development sizes from 0 to 50 ha and should linearly interpolate the formula to 50 ha.

So, catchment size	=	**46242**	m^2	Excluding significant open space which would remain disconnected from the positive drainage system during flood events.
	=	0.046	km^2	
	=	4.624	ha	
$QBAR_{rural\ site}$	=	0.03845	m^3/s	
	=	**38.45**	l/s	

GREENFIELD RETURN PERIOD ORDINATES

QBAR can be factored by the UK FSR regional growth curves for return periods <2 years and for all other return periods to obtain peak flow estimates for required return periods.

These regional growth curves are constant throughout a region, whatever the catchment type and size.

See Table 2.39 for region curve ordinates
Use FSSR2 Growth Curves to estimate Qbar

Reference- Pg 173-FSR V.1, ch 2.6.2

Region = **10**

Use Figure A1.1 to determine region

GREENFIELD RETURN PERIOD FLOW RATES

Return Period	Ordinate	Q (l/s)
1	0.87	33.45
2	0.93	35.76
5	1.19	45.75
10	1.38	53.06
25	1.64	63.06
30	1.7	65.36
50	1.85	71.13
100	2.08	79.97
200	2.32	89.20
500	2.73	104.96
1000	3.04	116.88

Ordinate from FSSR2

Interpolation taken from Figure 24.2 (pg 515) SuDS Manual

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ESTIMATE OF BROWNFIELD RUNOFF

Total site impermeable area, A = **21691** m²

M5-60 rainfall depth **17** mm

Ratio M5-60/M5-2Day, r **0.30**

[Flood Studies Report (NERC, 1975)]
[The Wallingford Proceedure - V4 Modified Rational Method, Fig A.2 (Hydraulics Research, 1983)]

Storm Duration 15 mins

Anticipated critical duration for the site - usually 15 minutes

Duration factor, Z1 0.59

[The Wallingford Proceedure - V4 Modified Rational Method, Fig A.3b (Hydraulics Research, 1983)]

M5-15 rainfall depth = 10.0 mm

Return period ratio, Z2

M1-15	0.61
M10-15	1.22
M30-15	1.49
M100-15	1.91

[The Wallingford Proceedure - V4 Modified Rational Method, Table A1 (Hydraulics Research, 1983)]

Rainfall

	Depth (mm)	**Intensity, i (mm/hr)**
M1-15	6.1	24
M10-15	12.2	49
M30-15	14.9	60
M100-15	19.2	77

Peak discharge, Qp = Cv Cr i A

Where:

Cv = Volumetric Runoff Coefficient
Cr = Routing Coefficient
i = Rainfall intensity (mm/hour)

Cv = 0.95
Cr = 1.3

Peak Runoff

	l/s
Q1	182.1
Q10	364.2
Q30	444.8
Q100	570.2

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Harras Road Whitehaven	Date 24/04/2024	Revised -

ESTIMATION OF QBAR (BROWNFIELD RUNOFF RATE)

See Table 2.39 for region curve ordinates

Use FSSR2 Growth Curves to estimate Qbar

Reference- Pg 173-FSR V.1, ch 2.6.2

Region = **10**

Use Figure A1.1 to determine region

Return Period	Ordinate
1	0.87
2	0.93
5	1.19
10	1.38
25	1.64
30	1.70
50	1.85
100	2.08
200	2.32
500	2.73
1000	3.04

Ordinate from FSSR2

Interpolation taken from Figure 24.2 (pg 515) SuDS Manual

Qbar

Ordinate used	l/s
10 year	263.9
30 year	261.7
100 year	274.1

Proposed Brownfield Runoff, Qbar = **266.58** l/s

Using the average Qbar derived from three ordinates.

Design Settings

Rainfall Methodology	FEH-22	Minimum Velocity (m/s)	1.00
Return Period (years)	100	Connection Type	Level Soffits
Additional Flow (%)	0	Minimum Backdrop Height (m)	0.200
CV	1.000	Preferred Cover Depth (m)	1.200
Time of Entry (mins)	5.00	Include Intermediate Ground	✓
Maximum Time of Concentration (mins)	30.00	Enforce best practice design rules	✓
Maximum Rainfall (mm/hr)	50.0		

Nodes

Name	Area (ha)	T of E (mins)	Cover Level (m)	Diameter (mm)	Easting (m)	Northing (m)	Depth (m)
1	0.036	5.00	144.582	1500	298787.740	518496.043	1.735
2	0.062	5.00	144.405	1500	298788.591	518467.656	1.747
3	0.083	5.00	144.884	1500	298822.277	518439.412	1.907
4	0.070	5.00	144.174	1500	298796.477	518439.229	1.713
5	0.091	5.00	143.930		298791.986	518432.086	3.030
6	0.000	5.00	143.500		298791.986	518375.086	2.742
7	0.000		143.500	1500	298791.980	518372.715	2.750
8	0.138	5.00	143.687	1800	298816.406	518350.843	3.046
9	0.099	5.00	144.676	1500	298855.879	518395.352	3.851
10	0.073	5.00	144.057	2100	298839.544	518377.119	3.533
11	0.109	5.00	143.605	1500	298871.918	518349.657	3.293
12	0.052	5.00	143.533	1500	298882.171	518345.122	3.277
13	0.111	5.00	143.373	1500	298887.200	518329.198	3.200
14	0.113	5.00	142.853	1500	298855.690	518293.653	2.918
15	0.016	5.00	142.769	1800	298853.699	518285.457	3.026
16	0.057	5.00	142.659	1500	298859.364	518276.145	2.943
17	0.138	5.00	141.756	1500	298906.649	518235.276	2.196
17_OUT	0.000		140.750		298929.476	518227.864	1.467
22	0.129	5.00	146.162	1500	298851.975	518479.966	1.684
23	0.016	5.00	146.197	1500	298851.975	518442.966	2.089
24	0.000	5.00	145.726	1500	298873.604	518435.144	1.848
25	0.103	5.00	145.408	1500	298884.385	518440.413	1.874
26	0.147	5.00	144.580	1500	298928.384	518440.769	1.331
27	0.057	5.00	145.546	1500	298882.709	518502.680	1.507
28	0.056	5.00	145.194	1500	298912.701	518501.984	1.455
29	0.019	5.00	144.739	1500	298949.692	518501.156	1.185
30	0.050	5.00	144.714	1500	298949.486	518492.309	1.204
31	0.034	5.00	144.448	1500	298942.682	518451.371	1.288
31_OUT	0.000		144.300		298959.023	518447.696	1.274
33	0.036	5.00	143.203	1500	298903.506	518324.393	1.508
34	0.055	5.00	142.933	1500	298916.494	518308.661	1.340
35	0.064	5.00	142.766	1500	298930.779	518300.110	1.256
36	0.026	5.00	143.000		298955.583	518340.600	1.000
37	0.000		143.000	1500	298954.598	518328.597	1.050
38	0.000		142.673		298954.716	518322.741	0.873
39	0.009	5.00	142.233		298952.751	518299.001	0.833
40	0.011	5.00	141.652		298952.183	518270.807	0.452
40_OUT	0.000		140.750		298942.647	518251.537	1.467
41	0.061	5.00	144.967	1500	298887.750	518412.748	1.873
42	0.023	5.00	144.595	1500	298901.374	518409.525	1.594
43	0.056	5.00	144.110	1500	298926.450	518388.942	1.306
44	0.103	5.00	143.950	1500	298938.321	518379.198	1.389

Nodes

Name	Area (ha)	T of E (mins)	Cover Level (m)	Diameter (mm)	Easting (m)	Northing (m)	Depth (m)
44_OUT	0.000		143.650		298956.621	518379.374	1.281
45	0.071	5.00	144.300		298960.739	518422.151	1.300
46	0.000		144.300	1800	298953.552	518415.491	1.349
46_OUT	0.000		143.650		298958.170	518397.875	1.281
47	0.064	5.00	140.750		298945.464	518218.771	1.500
48	0.000		140.750	1800	298947.931	518213.302	1.550
48_OUT			140.550	1500	298950.874	518206.921	1.465
49	0.019	5.00	143.650		298957.697	518378.738	1.300
49_OUT	0.000		143.000		298957.623	518368.446	0.972

Links

Name	US Node	DS Node	Length (m)	ks (mm) / n	US IL (m)	DS IL (m)	Fall (m)	Slope (1:X)	Dia (mm)	T of C (mins)	Rain (mm/hr)
1.000	1	2	28.400	0.600	142.847	142.658	0.189	150.0	300	5.37	50.0
1.001	2	4	29.501	0.600	142.658	142.461	0.197	150.0	300	5.75	50.0
2.000	3	4	25.801	0.600	142.977	142.461	0.516	50.0	300	5.19	50.0
1.002	4	5	8.438	0.600	142.461	142.400	0.061	138.3	300	5.86	50.0
1.003	5	6	57.000	0.600	140.900	140.758	0.142	400.0	1800	6.26	50.0
1.004	6	7	2.371	0.600	140.758	140.750	0.008	300.0	450	6.29	50.0
1.005	7	8	32.787	0.600	140.750	140.641	0.109	300.0	450	6.76	50.0
1.006	8	10	35.011	0.600	140.641	140.524	0.117	300.0	450	7.26	50.0
3.000	9	10	24.480	0.600	140.825	140.677	0.148	165.0	300	5.33	50.0
1.007	10	11	42.453	0.600	140.524	140.312	0.212	200.0	450	7.75	50.0
1.008	11	12	11.211	0.600	140.312	140.256	0.056	200.0	450	7.88	50.0
1.009	12	13	16.699	0.600	140.256	140.173	0.083	200.0	450	8.08	50.0
1.010	13	14	47.501	0.600	140.173	139.935	0.238	200.0	450	8.63	50.0
1.011	14	15	8.434	0.600	139.935	139.893	0.042	200.0	450	8.73	50.0
1.012	15	16	10.900	0.600	139.743	139.716	0.027	400.0	600	8.88	50.0
1.013	16	17	62.499	0.600	139.716	139.560	0.156	400.0	600	9.74	50.0
1.014	17	17_OUT	24.000	0.600	139.560	139.500	0.060	400.0	600	10.07	50.0

Name	Vel (m/s)	Cap (l/s)	Flow (l/s)	US Depth (m)	DS Depth (m)	Σ Area (ha)	Σ Add Inflow (l/s)	Pro Depth (mm)	Pro Velocity (m/s)
1.000	1.281	90.6	6.5	1.435	1.447	0.036	0.0	54	0.752
1.001	1.281	90.6	17.7	1.447	1.413	0.098	0.0	89	0.999
2.000	2.228	157.5	15.0	1.607	1.413	0.083	0.0	62	1.417
1.002	1.335	94.3	45.4	1.413	1.230	0.251	0.0	147	1.323
1.003	2.390	18248.9	61.8	1.230	0.942	0.342	0.0	73	0.584
1.004	1.168	185.8	61.8	2.292	2.300	0.342	0.0	178	1.054
1.005	1.168	185.8	61.8	2.300	2.596	0.342	0.0	178	1.054
1.006	1.168	185.8	86.7	2.596	3.083	0.480	0.0	216	1.148
3.000	1.221	86.3	17.9	3.551	3.080	0.099	0.0	92	0.969
1.007	1.434	228.0	117.8	3.083	2.843	0.652	0.0	230	1.446
1.008	1.434	228.0	137.5	2.843	2.827	0.761	0.0	253	1.498
1.009	1.434	228.0	146.9	2.827	2.750	0.813	0.0	263	1.519
1.010	1.434	228.0	167.0	2.750	2.468	0.924	0.0	287	1.560
1.011	1.434	228.0	187.4	2.468	2.426	1.037	0.0	312	1.593
1.012	1.211	342.4	190.3	2.426	2.343	1.053	0.0	320	1.241
1.013	1.211	342.4	200.6	2.343	1.596	1.110	0.0	331	1.257
1.014	1.211	342.4	225.5	1.596	0.650	1.248	0.0	357	1.290

Links

Name	US Node	DS Node	Length (m)	ks (mm) / n	US IL (m)	DS IL (m)	Fall (m)	Slope (1:X)	Dia (mm)	T of C (mins)	Rain (mm/hr)
4.000	22	23	37.000	0.600	144.478	144.108	0.370	100.0	300	5.39	50.0
4.001	23	24	23.000	0.600	144.108	143.878	0.230	100.0	300	5.64	50.0
4.002	24	25	12.000	0.600	143.878	143.684	0.194	61.9	300	5.74	50.0
4.003	25	26	44.000	0.600	143.534	143.249	0.285	154.4	450	6.18	50.0
4.004	26	31	17.800	0.600	143.249	143.160	0.089	200.0	450	6.39	50.0
5.000	27	28	30.000	0.600	144.039	143.739	0.300	100.0	300	5.32	50.0
5.001	28	29	37.000	0.600	143.739	143.554	0.185	200.0	300	5.87	50.0
5.002	29	30	8.849	0.600	143.554	143.510	0.044	200.0	300	6.01	50.0
5.003	30	31	41.500	0.600	143.510	143.310	0.200	207.5	300	6.64	50.0
4.005	31	31_OUT	16.749	0.600	143.160	143.075	0.085	197.0	450	6.84	50.0
6.000	33	34	20.401	0.600	141.695	141.593	0.102	200.0	300	5.31	50.0
6.001	34	35	16.649	0.600	141.593	141.510	0.083	200.0	300	5.56	50.0
6.002	35	39	22.000	0.600	141.510	141.400	0.110	200.0	300	5.89	50.0
7.000	36	37	12.043	0.600	142.000	141.950	0.050	240.9	300	5.20	50.0
7.001	37	38	5.857	0.600	141.950	141.800	0.150	39.0	300	5.24	50.0
7.002	38	39	23.821	0.600	141.800	141.400	0.400	59.6	600	5.32	50.0
6.003	39	40	28.200	0.600	141.400	141.200	0.200	141.0	600	6.03	50.0
6.004	40	40_OUT	21.500	0.600	141.200	140.000	1.200	17.9	225	6.15	50.0
8.000	41	42	14.000	0.600	143.094	143.001	0.093	150.5	300	5.18	50.0
8.001	42	43	32.442	0.600	143.001	142.804	0.197	165.0	300	5.63	50.0
8.002	43	44	15.358	0.600	142.804	142.711	0.093	165.0	300	5.83	50.0
8.003	44	44_OUT	18.301	0.600	142.561	142.500	0.061	300.0	450	6.10	50.0
9.000	45	46	9.798	0.600	143.000	142.951	0.049	200.0	300	5.15	50.0
9.001	46	46_OUT	18.211	0.600	142.951	142.860	0.091	200.0	300	5.42	50.0

Name	Vel (m/s)	Cap (l/s)	Flow (l/s)	US Depth (m)	DS Depth (m)	Σ Area (ha)	Σ Add Inflow (l/s)	Pro Depth (mm)	Pro Velocity (m/s)
4.000	1.572	111.1	23.3	1.384	1.789	0.129	0.0	93	1.252
4.001	1.572	111.1	26.2	1.789	1.548	0.145	0.0	99	1.293
4.002	2.002	141.5	26.2	1.548	1.424	0.145	0.0	87	1.541
4.003	1.633	259.8	44.8	1.424	0.881	0.248	0.0	125	1.233
4.004	1.434	228.0	71.4	0.881	0.838	0.395	0.0	173	1.275
5.000	1.572	111.1	10.3	1.207	1.155	0.057	0.0	61	0.993
5.001	1.108	78.3	20.4	1.155	0.885	0.113	0.0	104	0.935
5.002	1.108	78.3	23.9	0.885	0.904	0.132	0.0	113	0.976
5.003	1.087	76.9	32.9	0.904	0.838	0.182	0.0	137	1.046
4.005	1.444	229.7	110.4	0.838	0.775	0.611	0.0	220	1.432
6.000	1.108	78.3	6.5	1.208	1.040	0.036	0.0	58	0.679
6.001	1.108	78.3	16.4	1.040	0.956	0.091	0.0	93	0.882
6.002	1.108	78.3	28.0	0.956	0.533	0.155	0.0	124	1.019
7.000	1.008	71.3	4.7	0.700	0.750	0.026	0.0	52	0.576
7.001	2.523	178.4	4.7	0.750	0.573	0.026	0.0	33	1.099
7.002	5.060	6983.1	4.7	0.273	0.233	0.026	0.0	14	0.633
6.003	3.284	4532.0	34.3	0.233	-0.148	0.190	0.0	55	0.928
6.004	3.106	123.5	36.3	0.227	0.525	0.201	0.0	83	2.705
8.000	1.279	90.4	11.0	1.573	1.294	0.061	0.0	70	0.872
8.001	1.221	86.3	15.2	1.294	1.006	0.084	0.0	85	0.925
8.002	1.221	86.3	25.3	1.006	0.939	0.140	0.0	111	1.065
8.003	1.168	185.8	43.9	0.939	0.700	0.243	0.0	148	0.962
9.000	1.108	78.3	12.8	1.000	1.049	0.071	0.0	82	0.823
9.001	1.108	78.3	12.8	1.049	0.490	0.071	0.0	82	0.823

Links

Name	US Node	DS Node	Length (m)	ks (mm) / n	US IL (m)	DS IL (m)	Fall (m)	Slope (1:X)	Dia (mm)	T of C (mins)	Rain (mm/hr)
10.000	47	48	6.000	0.600	139.250	139.200	0.050	120.0	300	5.07	50.0
10.001	48	48_OUT	7.027	0.600	139.200	139.085	0.115	61.0	300	5.13	50.0
11.000	49	49_OUT	10.292	0.600	142.350	142.200	0.150	68.6	150	5.14	50.0

Name	Vel (m/s)	Cap (l/s)	Flow (l/s)	US Depth (m)	DS Depth (m)	Σ Area (ha)	Σ Add Inflow (l/s)	Pro Depth (mm)	Pro Velocity (m/s)
10.000	1.434	101.4	11.6	1.200	1.250	0.064	0.0	68	0.964
10.001	2.016	142.5	11.6	1.250	1.165	0.064	0.0	57	1.224
11.000	1.215	21.5	3.4	1.150	0.650	0.019	0.0	41	0.895

Pipeline Schedule

Link	Length (m)	Slope (1:X)	Dia (mm)	Link Type	US CL (m)	US IL (m)	US Depth (m)	DS CL (m)	DS IL (m)	DS Depth (m)
1.000	28.400	150.0	300	Circular_RGP	144.582	142.847	1.435	144.405	142.658	1.447
1.001	29.501	150.0	300	Circular_RGP	144.405	142.658	1.447	144.174	142.461	1.413
2.000	25.801	50.0	300	Circular_RGP	144.884	142.977	1.607	144.174	142.461	1.413
1.002	8.438	138.3	300	Circular_RGP	144.174	142.461	1.413	143.930	142.400	1.230
1.003	57.000	400.0	1800	3x1800 circular	143.930	140.900	1.230	143.500	140.758	0.942
1.004	2.371	300.0	450	Circular_Default Sewer Type	143.500	140.758	2.292	143.500	140.750	2.300
1.005	32.787	300.0	450	Circular_Default Sewer Type	143.500	140.750	2.300	143.687	140.641	2.596
1.006	35.011	300.0	450	Circular_Default Sewer Type	143.687	140.641	2.596	144.057	140.524	3.083
3.000	24.480	165.0	300	Circular_RGP	144.676	140.825	3.551	144.057	140.677	3.080
1.007	42.453	200.0	450	Circular_Default Sewer Type	144.057	140.524	3.083	143.605	140.312	2.843
1.008	11.211	200.0	450	Circular_Default Sewer Type	143.605	140.312	2.843	143.533	140.256	2.827
1.009	16.699	200.0	450	Circular_Default Sewer Type	143.533	140.256	2.827	143.373	140.173	2.750
1.010	47.501	200.0	450	Circular_Default Sewer Type	143.373	140.173	2.750	142.853	139.935	2.468
1.011	8.434	200.0	450	Circular_Default Sewer Type	142.853	139.935	2.468	142.769	139.893	2.426
1.012	10.900	400.0	600	Circular_Default Sewer Type	142.769	139.743	2.426	142.659	139.716	2.343
1.013	62.499	400.0	600	Circular_Default Sewer Type	142.659	139.716	2.343	141.756	139.560	1.596
1.014	24.000	400.0	600	Circular_Default Sewer Type	141.756	139.560	1.596	140.750	139.500	0.650

Link	US Node	Dia (mm)	Node Type	MH Type	DS Node	Dia (mm)	Node Type	MH Type
1.000	1	1500	Manhole	Adoptable	2	1500	Manhole	Adoptable
1.001	2	1500	Manhole	Adoptable	4	1500	Manhole	Adoptable
2.000	3	1500	Manhole	Adoptable	4	1500	Manhole	Adoptable
1.002	4	1500	Manhole	Adoptable	5		Junction	
1.003	5		Junction		6		Junction	
1.004	6		Junction		7	1500	Manhole	Adoptable
1.005	7	1500	Manhole	Adoptable	8	1800	Manhole	Adoptable
1.006	8	1800	Manhole	Adoptable	10	2100	Manhole	Adoptable
3.000	9	1500	Manhole	Adoptable	10	2100	Manhole	Adoptable
1.007	10	2100	Manhole	Adoptable	11	1500	Manhole	Adoptable
1.008	11	1500	Manhole	Adoptable	12	1500	Manhole	Adoptable
1.009	12	1500	Manhole	Adoptable	13	1500	Manhole	Adoptable
1.010	13	1500	Manhole	Adoptable	14	1500	Manhole	Adoptable
1.011	14	1500	Manhole	Adoptable	15	1800	Manhole	Adoptable
1.012	15	1800	Manhole	Adoptable	16	1500	Manhole	Adoptable
1.013	16	1500	Manhole	Adoptable	17	1500	Manhole	Adoptable
1.014	17	1500	Manhole	Adoptable	17_OUT		Junction	

Pipeline Schedule

Link	Length (m)	Slope (1:X)	Dia (mm)	Link Type	US CL (m)	US IL (m)	US Depth (m)	DS CL (m)	DS IL (m)	DS Depth (m)
4.000	37.000	100.0	300	Circular_RGP	146.162	144.478	1.384	146.197	144.108	1.789
4.001	23.000	100.0	300	Circular_RGP	146.197	144.108	1.789	145.726	143.878	1.548
4.002	12.000	61.9	300	Circular_RGP	145.726	143.878	1.548	145.408	143.684	1.424
4.003	44.000	154.4	450	Circular_RGP	145.408	143.534	1.424	144.580	143.249	0.881
4.004	17.800	200.0	450	Circular_RGP	144.580	143.249	0.881	144.448	143.160	0.838
5.000	30.000	100.0	300	Circular_RGP	145.546	144.039	1.207	145.194	143.739	1.155
5.001	37.000	200.0	300	Circular_RGP	145.194	143.739	1.155	144.739	143.554	0.885
5.002	8.849	200.0	300	Circular_RGP	144.739	143.554	0.885	144.714	143.510	0.904
5.003	41.500	207.5	300	Circular_RGP	144.714	143.510	0.904	144.448	143.310	0.838
4.005	16.749	197.0	450	Circular_RGP	144.448	143.160	0.838	144.300	143.075	0.775
6.000	20.401	200.0	300	Circular_RGP	143.203	141.695	1.208	142.933	141.593	1.040
6.001	16.649	200.0	300	Circular_RGP	142.933	141.593	1.040	142.766	141.510	0.956
6.002	22.000	200.0	300	Circular_RGP	142.766	141.510	0.956	142.233	141.400	0.533
7.000	12.043	240.9	300	Circular_RGP	143.000	142.000	0.700	143.000	141.950	0.750
7.001	5.857	39.0	300	Circular_RGP	143.000	141.950	0.750	142.673	141.800	0.573
7.002	23.821	59.6	600	swale	142.673	141.800	0.273	142.233	141.400	0.233
6.003	28.200	141.0	600	swale	142.233	141.400	0.233	141.652	141.200	-0.148
6.004	21.500	17.9	225	Circular_Default Sewer Type	141.652	141.200	0.227	140.750	140.000	0.525
8.000	14.000	150.5	300	Circular_RGP	144.967	143.094	1.573	144.595	143.001	1.294
8.001	32.442	165.0	300	Circular_RGP	144.595	143.001	1.294	144.110	142.804	1.006
8.002	15.358	165.0	300	Circular_RGP	144.110	142.804	1.006	143.950	142.711	0.939
8.003	18.301	300.0	450	Circular_RGP	143.950	142.561	0.939	143.650	142.500	0.700
9.000	9.798	200.0	300	Circular_RGP	144.300	143.000	1.000	144.300	142.951	1.049
9.001	18.211	200.0	300	Circular_RGP	144.300	142.951	1.049	143.650	142.860	0.490
10.000	6.000	120.0	300	Circular_RGP	140.750	139.250	1.200	140.750	139.200	1.250

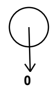
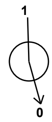
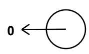
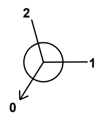
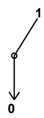
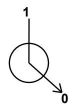
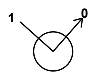
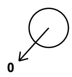
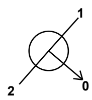
Link	US Node	Dia (mm)	Node Type	MH Type	DS Node	Dia (mm)	Node Type	MH Type
4.000	22	1500	Manhole	Adoptable	23	1500	Manhole	Adoptable
4.001	23	1500	Manhole	Adoptable	24	1500	Manhole	Adoptable
4.002	24	1500	Manhole	Adoptable	25	1500	Manhole	Adoptable
4.003	25	1500	Manhole	Adoptable	26	1500	Manhole	Adoptable
4.004	26	1500	Manhole	Adoptable	31	1500	Manhole	Adoptable
5.000	27	1500	Manhole	Adoptable	28	1500	Manhole	Adoptable
5.001	28	1500	Manhole	Adoptable	29	1500	Manhole	Adoptable
5.002	29	1500	Manhole	Adoptable	30	1500	Manhole	Adoptable
5.003	30	1500	Manhole	Adoptable	31	1500	Manhole	Adoptable
4.005	31	1500	Manhole	Adoptable	31_OUT		Junction	
6.000	33	1500	Manhole	Adoptable	34	1500	Manhole	Adoptable
6.001	34	1500	Manhole	Adoptable	35	1500	Manhole	Adoptable
6.002	35	1500	Manhole	Adoptable	39		Junction	
7.000	36		Junction		37	1500	Manhole	Adoptable
7.001	37	1500	Manhole	Adoptable	38		Junction	
7.002	38		Junction		39		Junction	
6.003	39		Junction		40		Junction	
6.004	40		Junction		40_OUT		Junction	
8.000	41	1500	Manhole	Adoptable	42	1500	Manhole	Adoptable
8.001	42	1500	Manhole	Adoptable	43	1500	Manhole	Adoptable
8.002	43	1500	Manhole	Adoptable	44	1500	Manhole	Adoptable
8.003	44	1500	Manhole	Adoptable	44_OUT		Junction	
9.000	45		Junction		46	1800	Manhole	Adoptable
9.001	46	1800	Manhole	Adoptable	46_OUT		Junction	
10.000	47		Junction		48	1800	Manhole	Adoptable

Pipeline Schedule

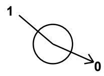
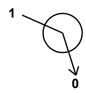
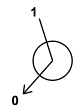
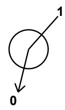
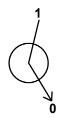
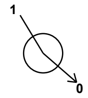
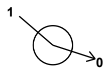
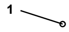
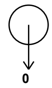
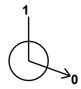
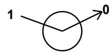
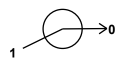
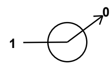
Link	Length (m)	Slope (1:X)	Dia (mm)	Link Type	US CL (m)	US IL (m)	US Depth (m)	DS CL (m)	DS IL (m)	DS Depth (m)
10.001	7.027	61.0	300	Circular_RGP	140.750	139.200	1.250	140.550	139.085	1.165
11.000	10.292	68.6	150	Circular_RGP	143.650	142.350	1.150	143.000	142.200	0.650

Link	US Node	Dia (mm)	Node Type	MH Type	DS Node	Dia (mm)	Node Type	MH Type
10.001	48	1800	Manhole	Adoptable	48_OUT	1500	Manhole	Adoptable
11.000	49		Junction		49_OUT		Junction	

Manhole Schedule

Node	Easting (m)	Northing (m)	CL (m)	Depth (m)	Dia (mm)	Connections		Link	IL (m)	Dia (mm)
1	298787.740	518496.043	144.582	1.735	1500		0	1.000	142.847	300
2	298788.591	518467.656	144.405	1.747	1500		1	1.000	142.658	300
							0	1.001	142.658	300
3	298822.277	518439.412	144.884	1.907	1500		0	2.000	142.977	300
4	298796.477	518439.229	144.174	1.713	1500		1	2.000	142.461	300
							2	1.001	142.461	300
							0	1.002	142.461	300
5	298791.986	518432.086	143.930	3.030			1	1.002	142.400	300
							0	1.003	140.900	1800
6	298791.986	518375.086	143.500	2.742			1	1.003	140.758	1800
							0	1.004	140.758	450
7	298791.980	518372.715	143.500	2.750	1500		1	1.004	140.750	450
							0	1.005	140.750	450
8	298816.406	518350.843	143.687	3.046	1800		1	1.005	140.641	450
							0	1.006	140.641	450
9	298855.879	518395.352	144.676	3.851	1500		0	3.000	140.825	300
10	298839.544	518377.119	144.057	3.533	2100		1	3.000	140.677	300
							2	1.006	140.524	450
							0	1.007	140.524	450

Manhole Schedule

Node	Easting (m)	Northing (m)	CL (m)	Depth (m)	Dia (mm)	Connections		Link	IL (m)	Dia (mm)
11	298871.918	518349.657	143.605	3.293	1500		1	1.007	140.312	450
							0	1.008	140.312	450
12	298882.171	518345.122	143.533	3.277	1500		1	1.008	140.256	450
							0	1.009	140.256	450
13	298887.200	518329.198	143.373	3.200	1500		1	1.009	140.173	450
							0	1.010	140.173	450
14	298855.690	518293.653	142.853	2.918	1500		1	1.010	139.935	450
							0	1.011	139.935	450
15	298853.699	518285.457	142.769	3.026	1800		1	1.011	139.893	450
							0	1.012	139.743	600
16	298859.364	518276.145	142.659	2.943	1500		1	1.012	139.716	600
							0	1.013	139.716	600
17	298906.649	518235.276	141.756	2.196	1500		1	1.013	139.560	600
							0	1.014	139.560	600
17_OUT	298929.476	518227.864	140.750	1.467			1	1.014	139.500	600
22	298851.975	518479.966	146.162	1.684	1500					
							0	4.000	144.478	300
23	298851.975	518442.966	146.197	2.089	1500		1	4.000	144.108	300
							0	4.001	144.108	300
24	298873.604	518435.144	145.726	1.848	1500		1	4.001	143.878	300
							0	4.002	143.878	300
25	298884.385	518440.413	145.408	1.874	1500		1	4.002	143.684	300
							0	4.003	143.534	450
26	298928.384	518440.769	144.580	1.331	1500		1	4.003	143.249	450
							0	4.004	143.249	450

Manhole Schedule

Node	Easting (m)	Northing (m)	CL (m)	Depth (m)	Dia (mm)	Connections	Link	IL (m)	Dia (mm)
27	298882.709	518502.680	145.546	1.507	1500	0	5.000	144.039	300
28	298912.701	518501.984	145.194	1.455	1500	1	5.000	143.739	300
						0	5.001	143.739	300
29	298949.692	518501.156	144.739	1.185	1500	1	5.001	143.554	300
						0	5.002	143.554	300
30	298949.486	518492.309	144.714	1.204	1500	1	5.002	143.510	300
						0	5.003	143.510	300
31	298942.682	518451.371	144.448	1.288	1500	1	5.003	143.310	300
						2	4.004	143.160	450
						0	4.005	143.160	450
31_OUT	298959.023	518447.696	144.300	1.274		1	4.005	143.075	450
33	298903.506	518324.393	143.203	1.508	1500	0	6.000	141.695	300
34	298916.494	518308.661	142.933	1.340	1500	1	6.000	141.593	300
						0	6.001	141.593	300
35	298930.779	518300.110	142.766	1.256	1500	1	6.001	141.510	300
						0	6.002	141.510	300
36	298955.583	518340.600	143.000	1.000		0	7.000	142.000	300
37	298954.598	518328.597	143.000	1.050	1500	1	7.000	141.950	300
						0	7.001	141.950	300
38	298954.716	518322.741	142.673	0.873		1	7.001	141.800	300
						0	7.002	141.800	600
39	298952.751	518299.001	142.233	0.833		1	7.002	141.400	600
						2	6.002	141.400	300
						0	6.003	141.400	600

Manhole Schedule

Node	Easting (m)	Northing (m)	CL (m)	Depth (m)	Dia (mm)	Connections	Link	IL (m)	Dia (mm)
40	298952.183	518270.807	141.652	0.452		1	6.003	141.200	600
						0	6.004	141.200	225
40_OUT	298942.647	518251.537	140.750	1.467		1	6.004	140.000	225
41	298887.750	518412.748	144.967	1.873	1500	0	8.000	143.094	300
42	298901.374	518409.525	144.595	1.594	1500	1	8.000	143.001	300
						0	8.001	143.001	300
43	298926.450	518388.942	144.110	1.306	1500	1	8.001	142.804	300
						0	8.002	142.804	300
44	298938.321	518379.198	143.950	1.389	1500	1	8.002	142.711	300
						0	8.003	142.561	450
44_OUT	298956.621	518379.374	143.650	1.281		1	8.003	142.500	450
45	298960.739	518422.151	144.300	1.300		0	9.000	143.000	300
46	298953.552	518415.491	144.300	1.349	1800	1	9.000	142.951	300
						0	9.001	142.951	300
46_OUT	298958.170	518397.875	143.650	1.281		1	9.001	142.860	300
47	298945.464	518218.771	140.750	1.500		0	10.000	139.250	300
48	298947.931	518213.302	140.750	1.550	1800	1	10.000	139.200	300
						0	10.001	139.200	300
48_OUT	298950.874	518206.921	140.550	1.465	1500	1	10.001	139.085	300

Manhole Schedule

Node	Easting (m)	Northing (m)	CL (m)	Depth (m)	Dia (mm)	Connections	Link	IL (m)	Dia (mm)
49	298957.697	518378.738	143.650	1.300		0	11.000	142.350	150
49_OUT	298957.623	518368.446	143.000	0.972		1	11.000	142.200	150

Simulation Settings

Rainfall Methodology	FEH-22	Skip Steady State	x	Check Discharge Volume	✓
Summer CV	0.750	Drain Down Time (mins)	240	100 year 360 minute (m³)	
Winter CV	0.840	Additional Storage (m³/ha)	20.0		
Analysis Speed	Detailed	Check Discharge Rate(s)	✓		

Storm Durations

15	60	180	360	600	960	2160
30	120	240	480	720	1440	2880

Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)
2	0	40	0
30	0	40	0
100	0	40	0
100	50	40	0

Pre-development Discharge Rate

Site Makeup	Greenfield	Growth Factor 30 year	1.95
Greenfield Method	IH124	Growth Factor 100 year	2.48
Positively Drained Area (ha)		Betterment (%)	0
SAAR (mm)		QBar	
Soil Index	1	Q 1 year (l/s)	
SPR	0.10	Q 30 year (l/s)	
Region	1	Q 100 year (l/s)	
Growth Factor 1 year	0.85		

Pre-development Discharge Volume

Site Makeup	Greenfield	Return Period (years)	100
Greenfield Method	FSR/FEH	Climate Change (%)	0
Positively Drained Area (ha)		Storm Duration (mins)	360
Soil Index	1	Betterment (%)	0
SPR	0.10	PR	
CWI		Runoff Volume (m³)	

Node 48 Online Hydro-Brake® Control

Flap Valve	x	Objective	(HE) Minimise upstream storage
Replaces Downstream Link	✓	Sump Available	✓
Invert Level (m)	139.200	Product Number	CTL-SHE-0256-3840-1550-3840
Design Depth (m)	1.550	Min Outlet Diameter (m)	0.300
Design Flow (l/s)	38.4	Min Node Diameter (mm)	1800

Node 37 Online Hydro-Brake® Control

Flap Valve	x	Objective	(HE) Minimise upstream storage
Replaces Downstream Link	✓	Sump Available	✓
Invert Level (m)	141.950	Product Number	CTL-SHE-0194-1900-1000-1900
Design Depth (m)	1.000	Min Outlet Diameter (m)	0.225
Design Flow (l/s)	19.0	Min Node Diameter (mm)	1500

Node 46 Online Hydro-Brake® Control

Flap Valve	x	Objective	(HE) Minimise upstream storage
Replaces Downstream Link	✓	Sump Available	✓
Invert Level (m)	142.951	Product Number	CTL-SHE-0122-7300-1300-7300
Design Depth (m)	1.300	Min Outlet Diameter (m)	0.150
Design Flow (l/s)	7.3	Min Node Diameter (mm)	1200

Node 10 Online Hydro-Brake® Control

Flap Valve	x	Objective	(HE) Minimise upstream storage
Replaces Downstream Link	✓	Sump Available	✓
Invert Level (m)	140.524	Product Number	CTL-SHE-0144-1320-2400-1320
Design Depth (m)	2.400	Min Outlet Diameter (m)	0.225
Design Flow (l/s)	13.2	Min Node Diameter (mm)	1500

Node 47 Flow through Pond Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Porosity	1.00	Main Channel Length (m)	33.079
Side Inf Coefficient (m/hr)	0.00000	Invert Level (m)	139.250	Main Channel Slope (1:X)	1000.0
Safety Factor	2.0	Time to half empty (mins)		Main Channel n	0.350

Inlets

40_OUT	17_OUT

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	391.1	0.0	0.400	525.8	0.0	0.800	632.4	0.0	1.200	747.4	0.0
0.100	451.3	0.0	0.500	551.7	0.0	0.900	660.4	0.0	1.300	777.5	0.0
0.200	475.6	0.0	0.600	578.1	0.0	1.000	688.9	0.0	1.400	808.0	0.0
0.300	500.5	0.0	0.700	605.0	0.0	1.100	717.9	0.0	1.500	851.8	0.0

Node 45 Flow through Pond Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Porosity	1.00	Main Channel Length (m)	25.600
Side Inf Coefficient (m/hr)	0.00000	Invert Level (m)	143.000	Main Channel Slope (1:X)	1000.0
Safety Factor	2.0	Time to half empty (mins)		Main Channel n	0.350

Inlets

31_OUT

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	261.6	0.0	0.400	433.7	0.0	0.800	615.3	0.0	1.200	806.1	0.0
0.100	303.6	0.0	0.500	478.2	0.0	0.900	662.1	0.0	1.300	856.9	0.0
0.200	346.4	0.0	0.600	523.3	0.0	1.000	709.5	0.0			
0.300	389.8	0.0	0.700	569.0	0.0	1.100	757.5	0.0			

Node 49 Flow through Pond Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Porosity	1.00	Main Channel Length (m)	19.143
Side Inf Coefficient (m/hr)	0.00000	Invert Level (m)	142.350	Main Channel Slope (1:X)	1000.0
Safety Factor	2.0	Time to half empty (mins)	0	Main Channel n	0.350

Inlets

46_OUT	44_OUT

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	25.6	0.0	0.400	74.8	0.0	0.800	133.3	0.0	1.200	201.1	0.0
0.100	37.0	0.0	0.500	88.6	0.0	0.900	149.4	0.0	1.300	222.1	0.0
0.200	49.0	0.0	0.600	102.9	0.0	1.000	166.1	0.0			
0.300	61.6	0.0	0.700	117.9	0.0	1.100	183.3	0.0			

Node 36 Flow through Pond Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Porosity	1.00	Main Channel Length (m)	27.921
Side Inf Coefficient (m/hr)	0.00000	Invert Level (m)	142.000	Main Channel Slope (1:X)	1000.0
Safety Factor	2.0	Time to half empty (mins)	116	Main Channel n	0.350

Inlets

49_OUT

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	25.7	0.0	0.300	78.3	0.0	0.600	137.1	0.0	0.900	201.9	0.0
0.100	42.5	0.0	0.400	97.2	0.0	0.700	158.0	0.0	1.000	267.4	0.0
0.200	60.1	0.0	0.500	116.8	0.0	0.800	179.6	0.0			

Results for 2 year +40% A Critical Storm Duration. Lowest mass balance: 99.69%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute winter	1	10	142.901	0.054	6.7	0.1270	0.0000	OK
15 minute winter	2	11	142.747	0.089	18.1	0.2450	0.0000	OK
15 minute winter	3	10	143.040	0.063	15.5	0.1872	0.0000	OK
15 minute winter	4	11	142.615	0.154	45.8	0.4489	0.0000	OK
180 minute winter	5	136	141.171	0.271	20.9	0.2281	0.0000	OK
180 minute winter	6	136	141.171	0.413	16.2	0.0000	0.0000	OK
180 minute winter	7	136	141.171	0.421	11.3	0.7444	0.0000	OK
180 minute winter	8	136	141.171	0.530	13.7	2.0226	0.0000	SURCHARGED
180 minute winter	9	140	141.172	0.347	6.0	0.8621	0.0000	SURCHARGED
180 minute winter	10	136	141.171	0.647	15.3	2.6166	0.0000	SURCHARGED
15 minute winter	11	10	140.441	0.129	32.5	0.3486	0.0000	OK
15 minute winter	12	10	140.399	0.143	41.9	0.3160	0.0000	OK
15 minute winter	13	10	140.333	0.160	62.1	0.4379	0.0000	OK
15 minute winter	14	11	140.142	0.207	81.8	0.5914	0.0000	OK
15 minute winter	15	11	139.975	0.232	85.1	0.6248	0.0000	OK
15 minute winter	16	11	139.936	0.220	94.9	0.5078	0.0000	OK
15 minute winter	17	12	139.798	0.238	118.1	0.8385	0.0000	OK
240 minute winter	17_OUT	184	139.673	0.390	43.2	0.0000	0.0000	OK
15 minute winter	22	10	144.573	0.095	24.1	0.3724	0.0000	OK
15 minute winter	23	11	144.212	0.104	26.7	0.2063	0.0000	OK
15 minute winter	24	11	143.973	0.095	26.5	0.1679	0.0000	OK
15 minute winter	25	11	143.658	0.124	44.8	0.4114	0.0000	OK
15 minute winter	26	11	143.445	0.196	70.8	0.9521	0.0000	OK
15 minute winter	27	10	144.101	0.061	10.6	0.1737	0.0000	OK
15 minute winter	28	10	143.843	0.104	20.9	0.2959	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
15 minute winter	1	1.000	2	6.5	0.511	0.072	0.3682	
15 minute winter	2	1.001	4	17.6	0.661	0.195	0.7947	
15 minute winter	3	2.000	4	15.3	0.685	0.097	0.6047	
15 minute winter	4	1.002	5	45.3	1.294	0.481	0.2958	
180 minute winter	5	1.003	6	16.2	0.177	0.001	57.9507	
180 minute winter	6	1.004	7	11.3	0.606	0.061	0.3635	
180 minute winter	7	1.005	8	11.7	0.460	0.063	5.1260	
180 minute winter	8	1.006	10	12.0	0.244	0.065	5.5473	
180 minute winter	9	3.000	10	6.5	0.503	0.076	1.7239	
180 minute winter	10	Hydro-Brake®	11	12.5				
15 minute winter	11	1.008	12	32.2	0.798	0.141	0.4532	
15 minute winter	12	1.009	13	41.4	0.888	0.182	0.7820	
15 minute winter	13	1.010	14	61.9	1.020	0.272	2.8885	
15 minute winter	14	1.011	15	82.3	1.246	0.361	0.5569	
15 minute winter	15	1.012	16	84.9	0.876	0.248	1.0576	
15 minute winter	16	1.013	17	93.8	0.956	0.274	6.1448	
15 minute winter	17	1.014	17_OUT	116.5	1.187	0.340	2.3574	
240 minute winter	17_OUT	Flow through pond	47	53.3	0.020	0.031	191.5214	
15 minute winter	22	4.000	23	23.7	1.161	0.213	0.7551	
15 minute winter	23	4.001	24	26.5	1.300	0.239	0.4696	
15 minute winter	24	4.002	25	26.7	1.475	0.189	0.2172	
15 minute winter	25	4.003	26	44.9	0.888	0.173	2.2411	
15 minute winter	26	4.004	31	70.4	0.972	0.309	1.2893	
15 minute winter	27	5.000	28	10.4	0.658	0.094	0.4804	
15 minute winter	28	5.001	29	20.6	0.812	0.263	0.9467	

Results for 2 year +40% A Critical Storm Duration. Lowest mass balance: 99.69%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute winter	29	11	143.685	0.131	23.9	0.2905	0.0000	OK
15 minute winter	30	11	143.648	0.138	32.5	0.4043	0.0000	OK
15 minute winter	31	11	143.384	0.224	107.8	0.5606	0.0000	OK
360 minute winter	31_OUT	272	143.379	0.354	24.8	0.0000	0.0000	OK
15 minute winter	33	10	141.753	0.058	6.7	0.1414	0.0000	OK
15 minute winter	34	11	141.690	0.097	16.8	0.2824	0.0000	OK
15 minute winter	35	11	141.634	0.124	28.2	0.3953	0.0000	OK
120 minute winter	36	90	142.344	0.344	24.9	0.2507	0.0000	SURCHARGED
120 minute winter	37	90	142.340	0.390	19.3	0.6887	0.0000	SURCHARGED
240 minute summer	38	140	141.831	0.031	19.0	0.0000	0.0000	OK
120 minute summer	39	64	141.455	0.055	34.4	0.0166	0.0000	OK
120 minute summer	40	64	141.282	0.082	35.4	0.0558	0.0000	OK
240 minute winter	40_OUT	180	139.689	0.406	27.8	0.0000	0.0000	OK
15 minute winter	41	10	143.169	0.075	11.4	0.2012	0.0000	OK
15 minute winter	42	11	143.085	0.084	15.5	0.1828	0.0000	OK
15 minute winter	43	11	142.922	0.118	25.5	0.3498	0.0000	OK
15 minute winter	44	11	142.715	0.154	43.4	0.5904	0.0000	OK
15 minute winter	44_OUT	13	142.682	0.313	43.0	0.0000	0.0000	OK
360 minute winter	45	272	143.380	0.380	17.4	0.5805	0.0000	SURCHARGED
360 minute winter	46	272	143.379	0.428	11.5	1.0895	0.0000	SURCHARGED
15 minute winter	46_OUT	13	142.676	0.306	7.1	0.0000	0.0000	OK
240 minute winter	47	184	139.671	0.421	56.6	0.5036	0.0000	SURCHARGED
240 minute winter	48	184	139.660	0.460	38.4	1.1712	0.0000	SURCHARGED
15 minute summer	48_OUT	1	139.085	0.000	29.1	0.0000	0.0000	OK
30 minute winter	49	24	142.620	0.270	40.0	0.1104	0.0000	SURCHARGED

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
15 minute winter	29	5.002	30	23.7	0.776	0.303	0.2708	
15 minute winter	30	5.003	31	31.5	1.033	0.410	1.2745	
15 minute winter	31	4.005	31_OUT	106.6	1.414	0.464	1.2698	
360 minute winter	31_OUT	Flow through pond	45	14.6	0.011	0.010	124.7332	
15 minute winter	33	6.000	34	6.5	0.456	0.084	0.2972	
15 minute winter	34	6.001	35	16.5	0.701	0.210	0.3917	
15 minute winter	35	6.002	39	28.1	1.622	0.359	0.3952	
120 minute winter	36	7.000	37	19.3	0.475	0.271	0.8481	
120 minute winter	37	Hydro-Brake®	38	19.0				
240 minute summer	38	7.002	39	19.0	0.852	0.003	0.6108	
120 minute summer	39	6.003	40	34.3	0.711	0.008	1.3757	
120 minute summer	40	6.004	40_OUT	35.2	2.700	0.285	0.2802	
240 minute winter	40_OUT	Flow through pond	47	53.3	0.020	0.031	191.5214	
15 minute winter	41	8.000	42	11.2	0.752	0.124	0.2087	
15 minute winter	42	8.001	43	15.2	0.733	0.176	0.6788	
15 minute winter	43	8.002	44	25.3	1.031	0.293	0.3767	
15 minute winter	44	8.003	44_OUT	43.0	0.955	0.231	0.9596	
15 minute winter	44_OUT	Flow through pond	49	38.9	0.079	0.116	11.0096	
360 minute winter	45	9.000	46	11.5	0.326	0.147	0.6900	
360 minute winter	46	Hydro-Brake®	46_OUT	7.3				
15 minute winter	46_OUT	Flow through pond	49	38.9	0.079	0.116	11.0096	
240 minute winter	47	10.000	48	38.4	0.623	0.379	0.4225	
240 minute winter	48	Hydro-Brake®	48_OUT	38.3				677.7
30 minute winter	49	11.000	49_OUT	28.8	1.634	1.339	0.1799	

Results for 2 year +40% A Critical Storm Duration. Lowest mass balance: 99.69%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
120 minute winter	49_OUT	90	142.365	0.337	24.7	0.0000	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
120 minute winter	49_OUT	Flow through pond	36	23.0	0.060	0.158	18.8784	

Results for 30 year +40% A Critical Storm Duration. Lowest mass balance: 99.69%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute winter	1	10	142.924	0.077	13.5	0.1804	0.0000	OK
15 minute winter	2	10	142.787	0.129	36.5	0.3561	0.0000	OK
15 minute winter	3	10	143.066	0.089	31.2	0.2668	0.0000	OK
15 minute winter	4	11	142.715	0.254	92.8	0.7396	0.0000	OK
180 minute winter	5	172	141.577	0.677	37.6	0.5697	0.0000	OK
180 minute winter	6	172	141.578	0.820	31.4	0.0000	0.0000	SURCHARGED
180 minute winter	7	172	141.578	0.828	19.5	1.4627	0.0000	SURCHARGED
180 minute winter	8	172	141.578	0.936	20.3	3.5707	0.0000	SURCHARGED
180 minute winter	9	168	141.577	0.752	10.9	1.8700	0.0000	SURCHARGED
180 minute winter	10	172	141.577	1.053	18.4	4.2559	0.0000	SURCHARGED
15 minute winter	11	10	140.491	0.179	53.5	0.4816	0.0000	OK
15 minute winter	12	10	140.457	0.201	72.6	0.4453	0.0000	OK
15 minute winter	13	10	140.402	0.229	113.4	0.6263	0.0000	OK
15 minute winter	14	11	140.242	0.307	153.6	0.8761	0.0000	OK
15 minute winter	15	11	140.086	0.343	159.4	0.9225	0.0000	OK
15 minute winter	16	11	140.041	0.325	179.5	0.7506	0.0000	OK
360 minute winter	17	328	139.990	0.430	54.0	1.5167	0.0000	OK
360 minute winter	17_OUT	328	139.990	0.707	53.1	0.0000	0.0000	OK
15 minute winter	22	10	144.620	0.142	48.5	0.5546	0.0000	OK
15 minute winter	23	10	144.264	0.156	53.8	0.3092	0.0000	OK
15 minute winter	24	11	144.021	0.143	53.3	0.2523	0.0000	OK
15 minute winter	25	11	143.714	0.180	90.4	0.5953	0.0000	OK
480 minute winter	26	448	143.667	0.418	22.6	2.0328	0.0000	OK
15 minute winter	27	10	144.127	0.088	21.4	0.2480	0.0000	OK
15 minute winter	28	10	143.895	0.156	42.2	0.4438	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
15 minute winter	1	1.000	2	13.2	0.620	0.146	0.6130	
15 minute winter	2	1.001	4	35.6	0.763	0.393	1.3649	
15 minute winter	3	2.000	4	30.9	0.783	0.196	1.0410	
15 minute winter	4	1.002	5	91.2	1.490	0.967	0.5157	
180 minute winter	5	1.003	6	16.8	0.191	0.001	170.6784	
180 minute winter	6	1.004	7	-19.1	0.559	-0.103	0.3757	
180 minute winter	7	1.005	8	-19.5	0.470	-0.105	5.1949	
180 minute winter	8	1.006	10	12.2	0.253	0.066	5.5473	
180 minute winter	9	3.000	10	10.4	0.501	0.120	1.7239	
180 minute winter	10	Hydro-Brake®	11	12.5				
15 minute winter	11	1.008	12	53.0	0.834	0.232	0.7136	
15 minute winter	12	1.009	13	71.6	0.959	0.314	1.2489	
15 minute winter	13	1.010	14	112.5	1.147	0.493	4.6469	
15 minute winter	14	1.011	15	153.7	1.447	0.674	0.8953	
15 minute winter	15	1.012	16	159.4	0.991	0.465	1.7553	
15 minute winter	16	1.013	17	178.3	1.109	0.521	10.0622	
360 minute winter	17	1.014	17_OUT	53.1	0.935	0.155	5.5498	
360 minute winter	17_OUT	Flow through pond	47	59.0	0.020	0.035	371.9911	
15 minute winter	22	4.000	23	47.8	1.370	0.430	1.2907	
15 minute winter	23	4.001	24	53.3	1.524	0.480	0.8045	
15 minute winter	24	4.002	25	53.8	1.752	0.380	0.3683	
15 minute winter	25	4.003	26	90.7	1.004	0.349	4.0336	
480 minute winter	26	4.004	31	21.5	0.706	0.094	2.7770	
15 minute winter	27	5.000	28	21.1	0.786	0.190	0.8121	
15 minute winter	28	5.001	29	41.8	0.929	0.533	1.6852	

Results for 30 year +40% A Critical Storm Duration. Lowest mass balance: 99.69%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute winter	29	11	143.771	0.217	48.5	0.4818	0.0000	OK
15 minute winter	30	11	143.734	0.224	65.8	0.6568	0.0000	OK
480 minute winter	31	448	143.667	0.507	33.9	1.2711	0.0000	SURCHARGED
480 minute winter	31_OUT	448	143.667	0.641	32.7	0.0000	0.0000	OK
15 minute winter	33	10	141.778	0.083	13.5	0.2013	0.0000	OK
15 minute winter	34	10	141.745	0.152	34.0	0.4422	0.0000	OK
15 minute winter	35	11	141.695	0.185	57.0	0.5912	0.0000	OK
120 minute winter	36	112	142.595	0.595	29.0	0.4334	0.0000	SURCHARGED
120 minute winter	37	112	142.591	0.641	19.5	1.1334	0.0000	SURCHARGED
720 minute summer	38	375	141.831	0.031	19.0	0.0000	0.0000	OK
30 minute summer	39	19	141.481	0.081	69.8	0.0245	0.0000	OK
30 minute summer	40	19	141.324	0.124	73.4	0.0845	0.0000	OK
360 minute winter	40_OUT	328	140.005	0.722	31.2	0.0000	0.0000	OK
15 minute winter	41	10	143.205	0.111	22.9	0.2983	0.0000	OK
15 minute winter	42	10	143.123	0.122	31.3	0.2646	0.0000	OK
15 minute winter	43	11	142.984	0.180	51.7	0.5339	0.0000	OK
60 minute winter	44	43	142.878	0.317	54.1	1.2200	0.0000	OK
60 minute winter	44_OUT	43	142.878	0.509	51.9	0.0000	0.0000	OK
480 minute winter	45	448	143.667	0.667	22.1	1.0201	0.0000	SURCHARGED
480 minute winter	46	448	143.667	0.716	15.5	1.8215	0.0000	SURCHARGED
60 minute winter	46_OUT	43	142.876	0.507	7.3	0.0000	0.0000	OK
360 minute winter	47	328	139.989	0.739	63.5	0.8830	0.0000	SURCHARGED
360 minute winter	48	328	139.978	0.778	38.6	1.9810	0.0000	SURCHARGED
15 minute summer	48_OUT	1	139.085	0.000	37.4	0.0000	0.0000	OK
60 minute winter	49	44	142.869	0.519	49.6	0.2122	0.0000	SURCHARGED

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
15 minute winter	29	5.002	30	48.1	0.876	0.614	0.4918	
15 minute winter	30	5.003	31	65.0	1.211	0.846	2.2602	
480 minute winter	31	4.005	31_OUT	32.7	0.851	0.143	2.6538	
480 minute winter	31_OUT	Flow through pond	45	18.0	0.012	0.013	263.8178	
15 minute winter	33	6.000	34	13.3	0.521	0.169	0.5250	
15 minute winter	34	6.001	35	33.1	0.814	0.423	0.6764	
15 minute winter	35	6.002	39	56.4	1.892	0.720	0.6683	
120 minute winter	36	7.000	37	19.5	0.475	0.273	0.8481	
120 minute winter	37	Hydro-Brake®	38	19.0				
720 minute summer	38	7.002	39	19.0	0.837	0.003	0.6007	
30 minute summer	39	6.003	40	70.0	0.850	0.015	2.3746	
30 minute summer	40	6.004	40_OUT	73.2	3.267	0.593	0.4820	
360 minute winter	40_OUT	Flow through pond	47	59.0	0.020	0.035	371.9911	
15 minute winter	41	8.000	42	22.6	0.893	0.250	0.3544	
15 minute winter	42	8.001	43	30.6	0.870	0.354	1.1498	
15 minute winter	43	8.002	44	51.2	1.226	0.593	0.6412	
60 minute winter	44	8.003	44_OUT	51.9	0.762	0.279	2.3945	
60 minute winter	44_OUT	Flow through pond	49	45.4	0.072	0.135	29.1073	
480 minute winter	45	9.000	46	15.5	0.393	0.198	0.6900	
480 minute winter	46	Hydro-Brake®	46_OUT	7.3				
60 minute winter	46_OUT	Flow through pond	49	45.4	0.072	0.135	29.1073	
360 minute winter	47	10.000	48	38.6	0.621	0.381	0.4225	
360 minute winter	48	Hydro-Brake®	48_OUT	38.4				1167.4
60 minute winter	49	11.000	49_OUT	35.6	2.021	1.656	0.1812	

Results for 30 year +40% A Critical Storm Duration. Lowest mass balance: 99.69%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m^3)	Flood (m^3)	Status
120 minute winter	49_OUT	112	142.597	0.569	30.9	0.0000	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m^3)	Discharge Vol (m^3)
120 minute winter	49_OUT	Flow through pond	36	25.5	0.060	0.175	45.3304	

Results for 100 year +40% A Critical Storm Duration. Lowest mass balance: 99.69%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute winter	1	10	142.933	0.086	16.8	0.2017	0.0000	OK
15 minute winter	2	11	142.817	0.159	45.4	0.4383	0.0000	OK
15 minute winter	3	10	143.077	0.100	38.7	0.2986	0.0000	OK
15 minute winter	4	10	142.780	0.319	114.4	0.9292	0.0000	SURCHARGED
240 minute winter	5	232	141.851	0.951	39.4	0.7995	0.0000	OK
240 minute winter	6	232	141.851	1.093	32.5	0.0000	0.0000	SURCHARGED
240 minute winter	7	232	141.851	1.101	21.3	1.9451	0.0000	SURCHARGED
240 minute winter	8	232	141.851	1.210	22.1	4.6123	0.0000	SURCHARGED
240 minute winter	9	232	141.850	1.025	11.4	2.5496	0.0000	SURCHARGED
240 minute winter	10	232	141.850	1.326	19.3	5.3608	0.0000	SURCHARGED
15 minute winter	11	10	140.514	0.202	63.4	0.5452	0.0000	OK
15 minute winter	12	10	140.485	0.229	87.0	0.5057	0.0000	OK
15 minute winter	13	10	140.434	0.261	137.4	0.7137	0.0000	OK
15 minute winter	14	11	140.292	0.357	187.2	1.0185	0.0000	OK
720 minute winter	15	540	140.198	0.455	34.7	1.2242	0.0000	OK
720 minute winter	16	540	140.197	0.481	37.9	1.1116	0.0000	OK
720 minute winter	17	540	140.197	0.637	45.6	2.2469	0.0000	SURCHARGED
720 minute winter	17_OUT	540	140.203	0.920	43.8	0.0000	0.0000	OK
15 minute winter	22	10	144.640	0.162	60.2	0.6352	0.0000	OK
15 minute winter	23	10	144.287	0.179	66.8	0.3553	0.0000	OK
15 minute winter	24	11	144.042	0.164	66.1	0.2890	0.0000	OK
960 minute winter	25	765	143.867	0.333	11.5	1.1019	0.0000	OK
960 minute winter	26	765	143.867	0.618	18.4	3.0049	0.0000	SURCHARGED
15 minute winter	27	10	144.137	0.098	26.6	0.2776	0.0000	OK
15 minute winter	28	10	143.918	0.179	52.3	0.5097	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
15 minute winter	1	1.000	2	16.5	0.655	0.182	0.7688	
15 minute winter	2	1.001	4	43.6	0.777	0.481	1.5968	
15 minute winter	3	2.000	4	38.4	0.810	0.244	1.1734	
15 minute winter	4	1.002	5	111.2	1.602	1.179	0.5677	
240 minute winter	5	1.003	6	15.4	0.180	0.001	253.9132	
240 minute winter	6	1.004	7	-20.9	0.554	-0.113	0.3757	
240 minute winter	7	1.005	8	-21.3	0.455	-0.115	5.1949	
240 minute winter	8	1.006	10	12.1	0.255	0.065	5.5473	
240 minute winter	9	3.000	10	10.9	0.499	0.126	1.7239	
240 minute winter	10	Hydro-Brake®	11	12.5				
15 minute winter	11	1.008	12	62.7	0.842	0.275	0.8409	
15 minute winter	12	1.009	13	85.6	0.972	0.376	1.4701	
15 minute winter	13	1.010	14	136.1	1.176	0.597	5.4607	
15 minute winter	14	1.011	15	187.1	1.502	0.820	1.0469	
720 minute winter	15	1.012	16	34.7	0.728	0.101	2.5693	
720 minute winter	16	1.013	17	37.9	0.733	0.111	16.3757	
720 minute winter	17	1.014	17_OUT	43.8	0.860	0.128	6.7603	
720 minute winter	17_OUT	Flow through pond	47	53.4	0.017	0.031	502.6827	
15 minute winter	22	4.000	23	59.3	1.432	0.534	1.5323	
15 minute winter	23	4.001	24	66.1	1.593	0.595	0.9542	
15 minute winter	24	4.002	25	66.7	1.840	0.471	0.4349	
960 minute winter	25	4.003	26	11.5	0.626	0.044	6.2555	
960 minute winter	26	4.004	31	17.6	0.655	0.077	2.8203	
15 minute winter	27	5.000	28	26.2	0.824	0.236	0.9588	
15 minute winter	28	5.001	29	51.3	0.952	0.655	2.0559	

Results for 100 year +40% A Critical Storm Duration. Lowest mass balance: 99.69%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
960 minute winter	29	765	143.867	0.313	6.2	0.6945	0.0000	SURCHARGED
960 minute winter	30	765	143.867	0.357	8.5	1.0471	0.0000	SURCHARGED
960 minute winter	31	765	143.867	0.707	27.7	1.7724	0.0000	SURCHARGED
960 minute winter	31_OUT	765	143.867	0.841	27.1	0.0000	0.0000	OK
15 minute winter	33	10	141.788	0.093	16.8	0.2254	0.0000	OK
15 minute winter	34	10	141.770	0.177	42.2	0.5173	0.0000	OK
15 minute winter	35	11	141.719	0.209	70.8	0.6679	0.0000	OK
120 minute winter	36	122	142.712	0.712	29.6	0.5180	0.0000	FLOOD RISK
120 minute winter	37	122	142.708	0.758	19.5	1.3395	0.0000	FLOOD RISK
960 minute winter	38	540	141.831	0.031	19.0	0.0000	0.0000	OK
30 minute summer	39	19	141.491	0.091	88.4	0.0275	0.0000	OK
30 minute summer	40	19	141.343	0.143	91.1	0.0975	0.0000	OK
600 minute winter	40_OUT	480	140.207	0.924	29.9	0.0000	0.0000	OK
15 minute winter	41	10	143.221	0.127	28.5	0.3397	0.0000	OK
15 minute winter	42	10	143.139	0.138	38.8	0.2990	0.0000	OK
15 minute winter	43	11	143.013	0.209	64.2	0.6207	0.0000	OK
60 minute winter	44	44	142.996	0.435	68.5	1.6730	0.0000	OK
60 minute winter	44_OUT	44	142.995	0.626	64.5	0.0000	0.0000	OK
960 minute winter	45	765	143.867	0.867	18.8	1.3259	0.0000	SURCHARGED
960 minute winter	46	765	143.867	0.916	15.8	2.3307	0.0000	SURCHARGED
60 minute winter	46_OUT	44	142.992	0.623	7.3	0.0000	0.0000	OK
720 minute winter	47	540	140.193	0.943	57.0	1.1274	0.0000	SURCHARGED
720 minute winter	48	540	140.184	0.984	38.5	2.5051	0.0000	SURCHARGED
15 minute summer	48_OUT	1	139.085	0.000	38.0	0.0000	0.0000	OK
60 minute winter	49	45	142.988	0.638	57.1	0.2610	0.0000	SURCHARGED

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
960 minute winter	29	5.002	30	6.2	0.571	0.079	0.6231	
960 minute winter	30	5.003	31	8.5	0.683	0.111	2.9224	
960 minute winter	31	4.005	31_OUT	27.1	0.772	0.118	2.6538	
960 minute winter	31_OUT	Flow through pond	45	15.5	0.010	0.011	382.7855	
15 minute winter	33	6.000	34	16.5	0.539	0.211	0.6305	
15 minute winter	34	6.001	35	41.1	0.858	0.525	0.7969	
15 minute winter	35	6.002	39	71.4	2.054	0.912	0.7734	
120 minute winter	36	7.000	37	19.5	0.475	0.274	0.8481	
120 minute winter	37	Hydro-Brake®	38	19.0				
960 minute winter	38	7.002	39	19.0	0.805	0.003	0.5835	
30 minute summer	39	6.003	40	86.8	0.884	0.019	2.8652	
30 minute summer	40	6.004	40_OUT	91.5	3.434	0.741	0.5729	
600 minute winter	40_OUT	Flow through pond	47	55.6	0.018	0.033	501.0140	
15 minute winter	41	8.000	42	28.1	0.940	0.311	0.4190	
15 minute winter	42	8.001	43	38.1	0.912	0.441	1.3600	
15 minute winter	43	8.002	44	63.5	1.282	0.736	0.7606	
60 minute winter	44	8.003	44_OUT	64.5	0.752	0.347	2.8861	
60 minute winter	44_OUT	Flow through pond	49	51.8	0.071	0.154	40.7794	
960 minute winter	45	9.000	46	15.8	0.486	0.202	0.6900	
960 minute winter	46	Hydro-Brake®	46_OUT	7.3				
60 minute winter	46_OUT	Flow through pond	49	51.8	0.071	0.154	40.7794	
720 minute winter	47	10.000	48	38.5	0.620	0.380	0.4225	
720 minute winter	48	Hydro-Brake®	48_OUT	38.4				1804.2
60 minute winter	49	11.000	49_OUT	38.1	2.167	1.776	0.1812	

Results for 100 year +40% A Critical Storm Duration. Lowest mass balance: 99.69%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
120 minute winter	49_OUT	122	142.712	0.684	33.2	0.0000	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
120 minute winter	49_OUT	Flow through pond	36	25.6	0.060	0.176	62.1864	

Results for 100 year +50% CC +40% A Critical Storm Duration. Lowest mass balance: 99.69%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
720 minute winter	1	540	143.346	0.499	3.0	1.1719	0.0000	SURCHARGED
720 minute winter	2	540	143.346	0.688	8.2	1.8997	0.0000	SURCHARGED
720 minute winter	3	540	143.346	0.369	6.9	1.1016	0.0000	SURCHARGED
720 minute winter	4	540	143.346	0.885	21.0	2.5760	0.0000	SURCHARGED
720 minute winter	5	540	143.346	2.446	28.6	2.0568	0.0000	SURCHARGED
720 minute winter	6	540	143.346	2.588	23.0	0.0000	0.0000	FLOOD RISK
720 minute winter	7	540	143.346	2.596	14.7	4.5865	0.0000	FLOOD RISK
720 minute winter	8	540	143.346	2.704	15.2	10.3123	0.0000	SURCHARGED
720 minute winter	9	540	143.345	2.520	8.3	6.2678	0.0000	SURCHARGED
720 minute winter	10	540	143.345	2.821	15.1	11.4028	0.0000	SURCHARGED
1440 minute winter	11	1080	140.735	0.423	17.6	1.1399	0.0000	OK
1440 minute winter	12	1080	140.735	0.479	20.2	1.0586	0.0000	SURCHARGED
1440 minute winter	13	1080	140.734	0.561	26.1	1.5367	0.0000	SURCHARGED
1440 minute winter	14	1080	140.733	0.798	32.2	2.2744	0.0000	SURCHARGED
1440 minute winter	15	1080	140.732	0.989	32.5	2.6639	0.0000	SURCHARGED
1440 minute winter	16	1080	140.732	1.016	35.1	2.3460	0.0000	SURCHARGED
1440 minute winter	17	1080	140.732	1.171	41.3	4.1317	0.0000	SURCHARGED
1440 minute winter	17_OUT	1080	140.737	1.454	40.1	0.0000	0.0000	OK
15 minute winter	22	10	144.696	0.218	90.3	0.8541	0.0000	OK
15 minute winter	23	12	144.391	0.283	99.9	0.5606	0.0000	OK
2160 minute winter	24	1620	144.285	0.406	6.0	0.7182	0.0000	SURCHARGED
2160 minute winter	25	1620	144.284	0.750	10.3	2.4808	0.0000	SURCHARGED
2160 minute winter	26	1620	144.284	1.035	16.0	5.0319	0.0000	FLOOD RISK
15 minute winter	27	12	144.444	0.405	39.9	1.1455	0.0000	SURCHARGED
15 minute winter	28	12	144.411	0.672	73.1	1.9124	0.0000	SURCHARGED

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
720 minute winter	1	1.000	2	3.0	0.404	0.033	1.9999	
720 minute winter	2	1.001	4	8.2	0.543	0.091	2.0774	
720 minute winter	3	2.000	4	6.9	0.541	0.044	1.8169	
720 minute winter	4	1.002	5	21.0	1.058	0.223	0.5942	
720 minute winter	5	1.003	6	11.1	0.149	0.001	433.5013	
720 minute winter	6	1.004	7	-14.4	0.539	-0.078	0.3757	
720 minute winter	7	1.005	8	-14.7	0.462	-0.079	5.1949	
720 minute winter	8	1.006	10	11.1	0.241	0.060	5.5473	
720 minute winter	9	3.000	10	8.0	0.468	0.093	1.7239	
720 minute winter	10	Hydro-Brake®	11	14.0				
1440 minute winter	11	1.008	12	17.6	0.748	0.077	1.7551	
1440 minute winter	12	1.009	13	20.2	0.794	0.089	2.6458	
1440 minute winter	13	1.010	14	26.1	0.844	0.114	7.5262	
1440 minute winter	14	1.011	15	31.7	0.968	0.139	1.3363	
1440 minute winter	15	1.012	16	32.2	0.704	0.094	3.0703	
1440 minute winter	16	1.013	17	33.9	0.704	0.099	17.6045	
1440 minute winter	17	1.014	17_OUT	40.1	0.816	0.117	6.7603	
1440 minute winter	17_OUT	Flow through pond	47	50.6	0.016	0.030	902.2996	
15 minute winter	22	4.000	23	88.7	1.524	0.798	2.2364	
15 minute winter	23	4.001	24	97.1	1.675	0.874	1.6015	
2160 minute winter	24	4.002	25	6.0	0.963	0.042	0.8450	
2160 minute winter	25	4.003	26	9.9	0.563	0.038	6.9715	
2160 minute winter	26	4.004	31	16.9	0.596	0.074	2.8203	
15 minute winter	27	5.000	28	36.2	0.861	0.326	2.1126	
15 minute winter	28	5.001	29	63.2	0.977	0.807	2.6055	

Results for 100 year +50% CC +40% A Critical Storm Duration. Lowest mass balance: 99.69%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
2160 minute winter	29	1620	144.285	0.731	5.5	1.6188	0.0000	SURCHARGED
2160 minute winter	30	1620	144.285	0.774	7.3	2.2692	0.0000	SURCHARGED
2160 minute winter	31	1620	144.284	1.124	24.3	2.8175	0.0000	FLOOD RISK
2160 minute winter	31_OUT	1620	144.284	1.258	24.8	0.0000	0.0000	OK
15 minute winter	33	11	141.849	0.154	25.2	0.3753	0.0000	OK
15 minute winter	34	11	141.839	0.246	61.9	0.7175	0.0000	OK
15 minute winter	35	11	141.776	0.266	104.2	0.8481	0.0000	OK
180 minute winter	36	180	142.920	0.920	29.0	0.6699	0.0000	FLOOD RISK
180 minute winter	37	180	142.916	0.966	19.3	1.7066	0.0000	FLOOD RISK
30 minute winter	38	187	141.831	0.031	19.0	0.0000	0.0000	OK
15 minute winter	39	11	141.511	0.110	127.1	0.0335	0.0000	OK
15 minute winter	40	12	141.392	0.192	133.7	0.1304	0.0000	OK
1440 minute winter	40_OUT	1050	140.744	1.461	28.3	0.0000	0.0000	OK
30 minute winter	41	21	143.298	0.204	35.9	0.5474	0.0000	OK
30 minute winter	42	21	143.292	0.291	49.2	0.6325	0.0000	OK
60 minute winter	43	42	143.257	0.453	59.5	1.3445	0.0000	SURCHARGED
60 minute winter	44	45	143.246	0.685	97.0	2.6326	0.0000	SURCHARGED
60 minute winter	44_OUT	45	143.244	0.875	95.4	0.0000	0.0000	OK
2160 minute winter	45	1620	144.284	1.284	17.7	1.9636	0.0000	FLOOD RISK
2160 minute winter	46	1620	144.284	1.333	13.2	3.3915	0.0000	FLOOD RISK
60 minute winter	46_OUT	46	143.239	0.869	7.3	0.0000	0.0000	OK
1440 minute winter	47	1050	140.728	1.478	54.0	1.7666	0.0000	FLOOD RISK
1440 minute winter	48	1050	140.717	1.517	38.5	3.8615	0.0000	FLOOD RISK
15 minute summer	48_OUT	1	139.085	0.000	38.4	0.0000	0.0000	OK
60 minute winter	49	46	143.237	0.887	76.6	0.3627	0.0000	SURCHARGED

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
2160 minute winter	29	5.002	30	5.2	0.529	0.066	0.6231	
2160 minute winter	30	5.003	31	7.0	0.610	0.092	2.9224	
2160 minute winter	31	4.005	31_OUT	24.8	0.702	0.108	2.6538	
2160 minute winter	31_OUT	Flow through pond	45	14.9	0.009	0.011	691.5016	
15 minute winter	33	6.000	34	24.2	0.562	0.309	1.0025	
15 minute winter	34	6.001	35	61.0	0.958	0.779	1.0639	
15 minute winter	35	6.002	39	103.9	2.238	1.327	0.9843	
180 minute winter	36	7.000	37	19.3	0.473	0.271	0.8481	
180 minute winter	37	Hydro-Brake®	38	19.0				
30 minute winter	38	7.002	39	19.0	0.893	0.003	1.2322	
15 minute winter	39	6.003	40	126.5	0.921	0.028	4.1618	
15 minute winter	40	6.004	40_OUT	131.0	3.563	1.061	0.8134	
1440 minute winter	40_OUT	Flow through pond	47	50.6	0.016	0.030	902.2996	
30 minute winter	41	8.000	42	35.7	0.989	0.395	0.8468	
30 minute winter	42	8.001	43	48.1	0.919	0.558	2.2754	
60 minute winter	43	8.002	44	53.0	1.173	0.614	1.0815	
60 minute winter	44	8.003	44_OUT	95.4	0.778	0.513	2.8997	
60 minute winter	44_OUT	Flow through pond	49	68.5	0.069	0.204	72.1250	
2160 minute winter	45	9.000	46	13.2	0.411	0.168	0.6900	
2160 minute winter	46	Hydro-Brake®	46_OUT	7.4				
60 minute winter	46_OUT	Flow through pond	49	68.5	0.069	0.204	72.1250	
1440 minute winter	47	10.000	48	38.5	0.619	0.380	0.4225	
1440 minute winter	48	Hydro-Brake®	48_OUT	38.4				3138.7
60 minute winter	49	11.000	49_OUT	42.9	2.439	1.999	0.1812	

Results for 100 year +50% CC +40% A Critical Storm Duration. Lowest mass balance: 99.69%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
180 minute winter	49_OUT	180	142.920	0.892	34.7	0.0000	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
180 minute winter	49_OUT	Flow through pond	36	23.8	0.056	0.163	99.8329	

DESIGN BASIS MEMORANDUM - SUSTAINABLE DRAINAGE TREATMENT OF SURFACE WATER

Design Brief

The following calculations outline the recommended treatment requirements for a sustaionable drainage system as outlined in the SuDS Manual 2015. The method used is the simple index approach outlined in section 26.

The requirement for oil interceptors has been assessed in line with the now withdrawn Pollution Prevention Guidance document PPG3, produced by the Environment Agency. An oil interceptor is not required for the proposed development.

Treatment within SuDS components is affected by the flow rate and volume of water which passes through the component. It is not reasonable or practical to treat the entirety of the runoff for infrequent greater intensity design storms. In any case the majority of the pollutants are removed from surfaces by the more frequent rainfall events and in the first flush resulting from the initial runoff from the larger events.
and to a certain capacity.

The following references have been used in the preparation of these calculations:

- SUDS Manual, CIRIA Report C753, 2015
- Pollution Mitigation Indicies provided by Hydro International

Results Summary

Roof Area:

Treatment component 1 Detention basin

Treatment component 2 None

Indices	Suspended	Metals	Hydrocarbons
Pollution Hazard	0.2	0.2	0.05
Pollution Mitigation	0.5	0.5	0.6
Treatment Suitability	Adequate	Adequate	Adequate

Residential Parking:

Treatment component 1 Detention basin

Treatment component 2 None

Indices	Suspended	Metals	Hydrocarbons
Pollution Hazard	0.5	0.4	0.4
Pollution Mitigation	0.5	0.5	0.6
Treatment Suitability	Adequate	Adequate	Adequate

Residential Roads

Treatment component 1 Detention basin
Treatment component 2 None

Indices	Suspended	Metals	Hydrocarbons
Pollution Hazard	0.5	0.4	0.4
Pollution Mitigation	0.5	0.5	0.6
Treatment Suitability	Adequate	Adequate	Adequate

POLLUTION HAZARD INDEX

Source of Runoff	Pollution Hazard	Pollution Hazard Indices: Suspended Solids	Metals	Hydro-carbons
Residential roofing	Very low	0.2	0.2	0.05

POLLUTION MITIGATION INDEX

The receiving water body shall be: Surface Water

	Suds Component	Pollution Mitigation Indices: Suspended Solids	Metals	Hydro-carbons
1	Detention basin	0.5	0.5	0.6
2	None	0	0	0
3	None	0	0	0
4	None	0	0	0
	Total Pollution Mitigation Index	**0.5**	**0.5**	**0.6**

ASSESSMENT OF TREATMENT PROPOSAL

Indices	Suspended Solids	Metals	Hydro-carbons
Pollution Hazard	0.2	0.2	0.05
Pollution Mitigation	0.5	0.5	0.6
	Adequate	Adequate	Adequate

R G PARKINS Kendal | 01539 729393 Lancaster | 01524 32548	CALCULATION		Job No.	K40340	Page	3 of 4
	Job	Harras Dyke	Drg no.		Date	16/04/2024
		Whitehaven	Revision		Initial	RH
	Title	Sustainable Drainage - Treatment			Checked	

POLLUTION HAZARD INDEX

Source of Runoff	Pollution Hazard	Pollution Hazard Indices		
		Suspended Solids	Metals	Hydro-carbons
Individual driveway	Low	0.5	0.4	0.4

POLLUTION MITIGATION INDEX

The receiving water body shall be: Surface Water

Suds Component		Pollution Mitigation Indices		
		Suspended Solids	Metals	Hydro-carbons
1	Detention basin	0.5	0.5	0.6
2	None	0	0	0
3	None	0	0	0
4	None	0	0	0
Total Pollution Mitigation Index		**0.5**	**0.5**	**0.6**

ASSESSMENT OF TREATMENT PROPOSAL

Indices	Suspended Solids	Metals	Hydro-carbons
Pollution Hazard	0.5	0.4	0.4
Pollution Mitigation	0.5	0.5	0.6
	Adequate	**Adequate**	**Adequate**

R G PARKINS Kendal | 01539 729393 Lancaster | 01524 32548	CALCULATION		Job No.	K40340	Page	4 of 4
	Job	Harras Dyke	Drg no.		Date	16/04/2024
		Whitehaven	Revision		Initial	RH
	Title	Sustainable Drainage - Treatment			Checked	

POLLUTION HAZARD INDEX

Source of Runoff	Pollution Hazard	Pollution Hazard Indices		
		Suspended Solids	Metals	Hydro-carbons
Low traffic roads (e.g. residential roads and general access roads, < 300 traffic movements/day)	Low	0.5	0.4	0.4

POLLUTION MITIGATION INDEX

The receiving water body shall be: Surface Water

Suds Component		Pollution Mitigation Indices		
		Suspended Solids	Metals	Hydro-carbons
1	Detention basin	0.5	0.5	0.6
2	None	0	0	0
3	None	0	0	0
4	None	0	0	0
Total Pollution Mitigation Index		**0.5**	**0.5**	**0.6**

ASSESSMENT OF TREATMENT PROPOSAL

Indices	Suspended Solids	Metals	Hydro-carbons
Pollution Hazard	0.5	0.4	0.4
Pollution Mitigation	0.5	0.5	0.6
	Adequate	Adequate	Adequate

POLLUTION HAZARD INDEX

Source of Runoff	Pollution Hazard	Pollution Hazard Indices: Suspended Solids	Metals	Hydro-carbons
Low traffic roads (e.g. residential roads and general access roads, < 300 traffic movements/day)	Low	0.5	0.4	0.4

POLLUTION MITIGATION INDEX

The receiving water body shall be: Surface Water

Suds Component		Pollution Mitigation Indices: Suspended Solids	Metals	Hydro-carbons
1	Swale	0.5	0.6	0.6
2	Detention basin	0.5	0.5	0.6
3	None	0	0	0
4	None	0	0	0
	Total Pollution Mitigation Index	**0.75**	**0.85**	**0.9**

ASSESSMENT OF TREATMENT PROPOSAL

Indices	Suspended Solids	Metals	Hydro-carbons
Pollution Hazard	0.5	0.4	0.4
Pollution Mitigation	0.75	0.85	0.9
	Adequate	**Adequate**	**Adequate**

APPENDIX C

UU CORRESPONDENCE

Rachel Heron

From: wastewaterdeveloperservices@uuplc.co.uk
Sent: 24 April 2024 11:28
To: Rachel Heron
Subject: RE: 05510346 - Pre Development Enquiry- Harras Dyke Farm, Harras Road, Whitehaven

Good Morning,

Please accept this email as receipt of your updated application received on 23/04/2024 for the above development. This has now been logged on our system and the job reference is 05510346 we would ask that you quote this reference in all future correspondence.

I have reviewed your application (and attachments) and can confirm this is suitable to be passed to Thomas Bethell for technical assessment. You will receive their response within 10 working days.

Kind regards

Lois Williams
Developer Services Assistant
Developer Services & Metering
Customer Services
unitedutilities.com
Tel: 0345 072 6067 Option 2 for Wastewater Services)
Direct Tel:

If you feel you have received a good service from myself, please can you take two minutes to fill in the survey below. This will be much appreciated

Visit: *https://unitedutilities.thewowawards.co.uk/nominate*

--------------- Original Message ---------------
From: Rachel Heron [rachel.heron@rgparkins.com]
Sent: 24/04/2024 09:04
To: wastewaterdeveloperservices@uuplc.co.uk
Subject: RE: 05510346 - Pre Development Enquiry- Harras Dyke Farm, Harras Road, Whitehaven

Good Morning,

Thank you for your response to the below.

I am just emailing with an update, apologies I had thought there were 77 no. plots proposed on the site, when in actual fact there is 90 no. We are still proposing to split the flows into 2 no. UU manholes, and the estimated peak flows as follows:

1. UU MH 7303 = 1.53 l/s (33 no. plots)
2. UU MH 9003 = 2.64 l/s (57 no. plots)
3. Combined flows from site = 4.17 l/s.

Is this in principle still acceptable to UU?

Kind Regards,

Rachel Heron MSc

Engineer

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From: wastewaterdeveloperservices@uuplc.co.uk <wastewaterdeveloperservices@uuplc.co.uk>
Sent: Wednesday, April 3, 2024 2:27 PM
To: Rachel Heron <rachel.heron@rgparkins.com>
Subject: RE: 05510346 - Pre Development Enquiry- Harras Dyke Farm, Harras Road, Whitehaven

Good Afternoon Rachel,

Pre Development Enquiry- Harras Dyke Farm, Harras Road, Whitehaven CA28 6NN – UU ref 05510346

We have carried out an assessment of your application which is based on the information provided. This pre-development advice on your drainage strategy will be valid for 12 months. Your drainage strategy will need to be reviewed by other competent authorities as part of the planning process, and we advise that you carry out the

necessary site investigations to confirm the viability of your proposals.
If your investigations require access to our public sewer network, we ask that you contact our network engineers with a request for an access certificate via our main contact telephone number 0345 6723 723 or refer to the link below:
https://www.unitedutilities.com/builders-developers/working-near-our-assets/

Asset Protection:
I am aware there are significant clean water assets at this site and particular care is needed when designing the drainage layout. You will need to ensure the proposals are satisfactory with our clean water department – this will require determining the precise location of the water mains and providing any required protection measures/clearance distances before a drainage strategy can be confirmed as acceptable.

Foul Water
Foul flow from this site will be allowed to drain into the public foul water/combined sewer system. Ultimately, we have no objections to the proposal of two connections, with 48 plots (~2.22 l/s) connecting at UUMH7303 and 29 plots (~1.34 l/s) connecting at UUMH9003.
If you are able to identify an alternative, more suitable point of discharge, we request that you contact us at your earliest convenience so that we can assess suitability.

Surface Water
Thank you for providing the proposed drainage plan showing surface water is proposed to connect to an existing land drainage system which then connects to a watercourse. From a strategy point of view we would have no objections to this, however there would be adoptability concerns as we cannot adopt networks discharging to private assets unless the asset in question is a culverted watercourse. Are you please able to confirm if this drain is recognised as a formal culverted watercourse in the eyes of the LLFA? We would need to be assured the asset is in a good working order. Has the asset been surveyed between the proposed connection point and the downstream watercourse?

As for flow rates, United Utilities cannot agree discharge rates to such assets – this will need to be agreed with the LLFA.

I have also noticed there appears to be an online attenuation tank proposed. From an adoptability point of view there are maintenance issues involved with safely accessing large tanks. The land here also offers a chance for more sustainable attenuation features such as another basin or pond which should be looked into in the first instance. Failing that it may be simpler and more cost effective to have private offline storage here.

Levels
For low-lying sites, (where the ground level of the site or the level of a basement is below the ground level at the point where the drainage connects to the public sewer), care should be taken to ensure that the property is not at increased risk of flooding. If these circumstances exist, we recommend that you contact us to discuss further. It could affect the detailed design of your site and result in the need to incorporate appropriate mitigating measures in your drainage scheme.

Land drainage / Overland flows / track drainage
United Utilities have no obligation, and furthermore we do not accept land drainage, overland flows or track drainage into the pubic sewerage network under any circumstances

Existing Wastewater Assets Crossing the Site
We have reviewed our records and can confirm that there does not appear to be any charted public sewers located within the boundary of proposed development. However, due to the accuracy of the records and the public sewer transfer legislation in 2011, not all public sewers are shown on our records so we would ask that you proceed with caution and carry out your own site investigation works. If any uncharted sewers are identified while carrying out your works we would ask that you contact United Utilities at the earliest opportunity so that we can offer guidance and update our records.

Existing Water Assets Crossing the Site

It is the developer responsibility to identify utilities on-site. Where clean water assets are shown on our records, we recommend that you contact our Water Pre-Development Team, via the following email address: DeveloperServicesWater@uuplc.co.uk. Further information for this service can be found on our website via the link below:
https://www.unitedutilities.com/builders-developers/larger-developments/pre-development/water-pre-dev/

Connection Application

Although we may discuss and agree discharge points and rates in principle, please be aware that you will have to apply for a formal sewer connection. This is so that we can assess the method of construction, Health & Safety requirements and to ultimately inspect the connection when it is made. Details of the application process and the form itself can be obtained from our website by following the link below:
https://www.unitedutilities.com/builders-developers/wastewater-services/sewer-connections/sewer-connection/

We recommend that the detailed design should confirm the locations of all utilities in the area and ensure that any proposed drainage solution considers routing and clash checks where required.
If we can be of any further assistance please don't hesitate to contact us further.

Sewer Adoptions

You have indicated on your application form that you intend to put the sewers forward for adoption (including any SuDS components that can come within the meaning of a sewer).

United Utilities assess adoption applications based on the current Design & Construction Guidance and local practices which have now replaced 'Sewers For Adoption 6th Edition'.

We recommend that you submit a pre design assessment to the sewer adoption mailbox (SewerAdoptions@uuplc.co.uk) stating pre design assessment in the title

Please refer to links below to obtain further guidance:
https://www.unitedutilities.com/builders-developers/larger-developments/wastewater/sewer-adoptions/

Site drainage must be designed in accordance with Building Regulations, National Planning Policy, and local flood authority guidelines, we would recommend that you speak and make suitable agreements with the relevant statutory bodies.
If you intend to put forward your wastewater assets for adoption by United Utilities, the proposed detail design will be subject to a technical appraisal by an Adoption Engineer as we need to be sure that the proposals meets the requirements set out in the Design & Construction Guidance. The proposed design should give consideration to long term operability and give United Utilities a safe and cost effective proposal for the lifetime of the assets. In these cases, we strongly recommend that no construction commences until the detailed drainage design, submitted as part of the Section 104 application, has been assessed and accepted in writing by United Utilities. Any work carried out prior to the technical assessment being approved is done entirely at the developer's own risk and could be subject to change.

SuDS

If your development proposal incorporates any SuDS component(s) which interact with a sewer network you plan on offering for adoption to United Utilities; contact should be made with our technical team at your earliest convenience, please complete the 'Section 104 pre-application form : ' and include as much relevant detail as you can. These discussions can help prevent delays later in the development process.
Section 104 Pre application form (1b)

As per the sewerage sector guidance, all SuDS should be designed in accordance with the standards within the Design & construction guidance & the CIRIA SuDS manual (C753)

Codes For Adoption
The new Codes for Adoption are outlined on the Water UK Website. The link below takes you to their webpage:
https://www.water.org.uk/technical-guidance/developers-services/codes-for-adoption/
A free copy of the new Design & Construction Guidance can be downloaded via the link below:
https://www.water.org.uk/sewerage-sector-guidance-approved-documents/

Kind regards,

Tom

United Utilities
Water for the North West

Thomas Bethell
Developer Engineer
Developer Services & Metering
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--------------- Original Message ---------------
From: Rachel Heron [rachel.heron@rgparkins.com]
Sent: 26/03/2024 11:00
To: wastewaterdeveloperservices@uuplc.co.uk
Subject: Pre Development Enquiry- Harras Dyke Farm, Harras Road, Whitehaven

Good Morning,

We have been asked to produce a Drainage Strategy for a proposed housing development at Harras Dyke Farm at Harras Road, Whitehaven. The development will comprise 77 no. residential dwellings, with associated access roads, driveways and landscaped areas.

It is proposed that foul flows from the site will be conveyed within an adoptable pipe network discharging into the UU 150 mm dia. public foul sewer. Due to the topography, there will need to be 2 no. connections into this system. The north and eastern portion of the site (48 no. plots) will discharge to UU MH 7303 at a predicted peak flow rate of 2.22 l/s, with the remaining 29 no. plots will discharge into UU MH 9003 (1.34 l/s).

Surface water will be attenuated within a series of box culverts within the proposed highways, before discharging into a detention basin to receive the required treatment. Numerous CCTV surveys have confirmed there is an existing surface water pipe in the low point of the site (where the basin will be located). A flow control will limit flows into this outlet pipe, which crosses under Red Lonning, and discharging into a watercourse within the golf course.

Are these proposals in principle acceptable to UU?

Post Code CA28 6NN

Grid Reference 298880E 518392N

Regards,

Rachel Heron MSc

Engineer

[Image is no longer available]