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Flood Risk Assessment & Drainage Strategy



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## 1. Introduction

This document has been prepared on behalf of TOWN. (the "Applicant") to support a Full Planning Application for the redevelopment of Nile + Villiers (the "Site") and provides a full justification as to why the proposal should be deemed acceptable in relation to Flood Risk and drainage strategy.

This report has been created in support of the planning application for the proposed development and aims to assess it against the risk of flooding and to establish the principles of the drainage scheme in line with the National Planning Policy Framework (NPPF), Planning Practice Guidance (PPG) and the Non-Statutory Technical Standards for Sustainable Drainage Systems, as well as local/regional policy and guidance.

## 2. Development Proposal

The Nile + Villiers site is an existing brownfield site in East Sunniside, Sunderland. The development proposal is for a mixed-use development of 75 homes and approximately 575 m² of commercial space, private and communal gardens, associated infrastructure and sustainable drainage systems (SuDS).

Civic Engineers (CE) have been appointed as structural engineering, civil engineering, and transport consultants for the development of the site.

The brief for Nile & Villiers includes:

- Providing a mix of residential types, including 2b4p – 3b5p houses and 2b3p maisonettes for both rent and sale;
- Re-instating an active frontage onto High Street West by providing a new mixed-use building with commercial and/or community use at the ground floor and residential above;
- Increasing building heights towards the north of the site by continuing the 12m building line of 177 High Street West, and stepping down to two-to-three storey terraces of residential houses to the south (with slightly higher duplexes marking the corners);
- Designing a contemporary scheme that optimises opportunities for off-site manufacture and assembly, whilst being informed by the character of the conservation areas by reinstating the frontage onto High Street West and historic terraced urban grain of the site;
- A multi-user route connecting Norfolk Street to Villiers Street, providing pedestrian and cycle alternatives to High Street West and Coronation Street. Street corners will be articulated by greater height of four storey residential properties, improving wayfinding.

## 3. Existing Site

### 3.1 Description

The site is split into two areas. The smaller area is located at 19-21 Nile Street. The larger area is bordered by Villiers Street to the East, Coronation Street to the South, Nile Street to the West and High Street West to the North. It consists of a brownfield site containing; a pathway/road running through the centre of the site from north to south and 2 car parks, one private car park in the south-east corner and the other (a public car park) in the north end of the site. The total site area is approximately 0.81ha and the location is shown below, in Figure 1.

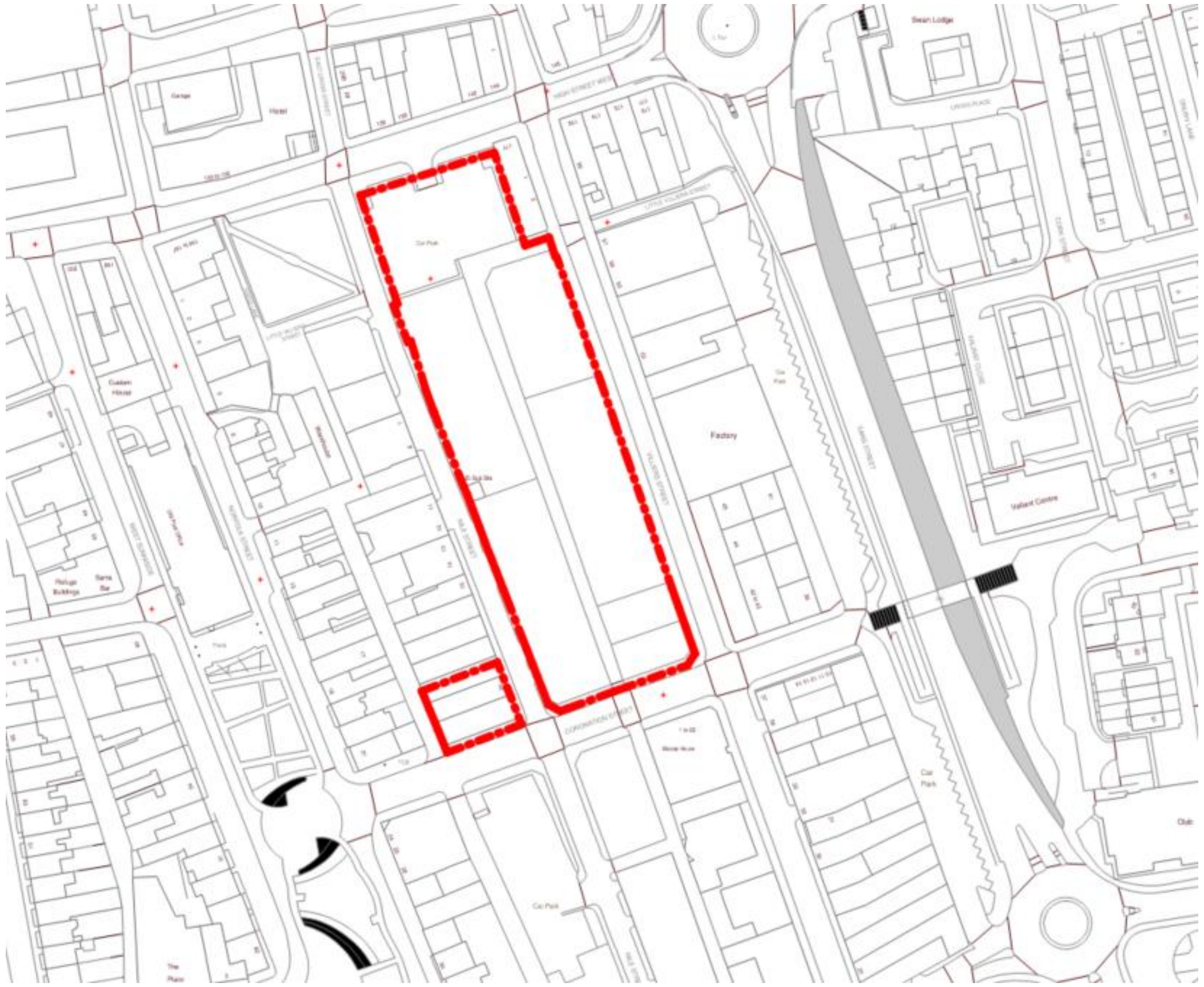


*Figure 1: Site location plan (by Xsite)*

## 3.2 Topography

Ground levels on the site are relatively consistent, at around 30 – 31m, with exception to the northeast corner on the intersection between Villiers Street and High Street West where levels dip to 28m.

The through road spanning the length of the site is relatively flat with levels ranging from 31m in the south to 29m in the north side. A topographical survey by Landform Surveys has been included in Appendix B.

## 3.3 Waterbodies

The River Wear lies just over 300m north from the centre of the site, Mowbray Park Lake is just over 400m south-west from the centre of the site, as shown below in Figure 2.

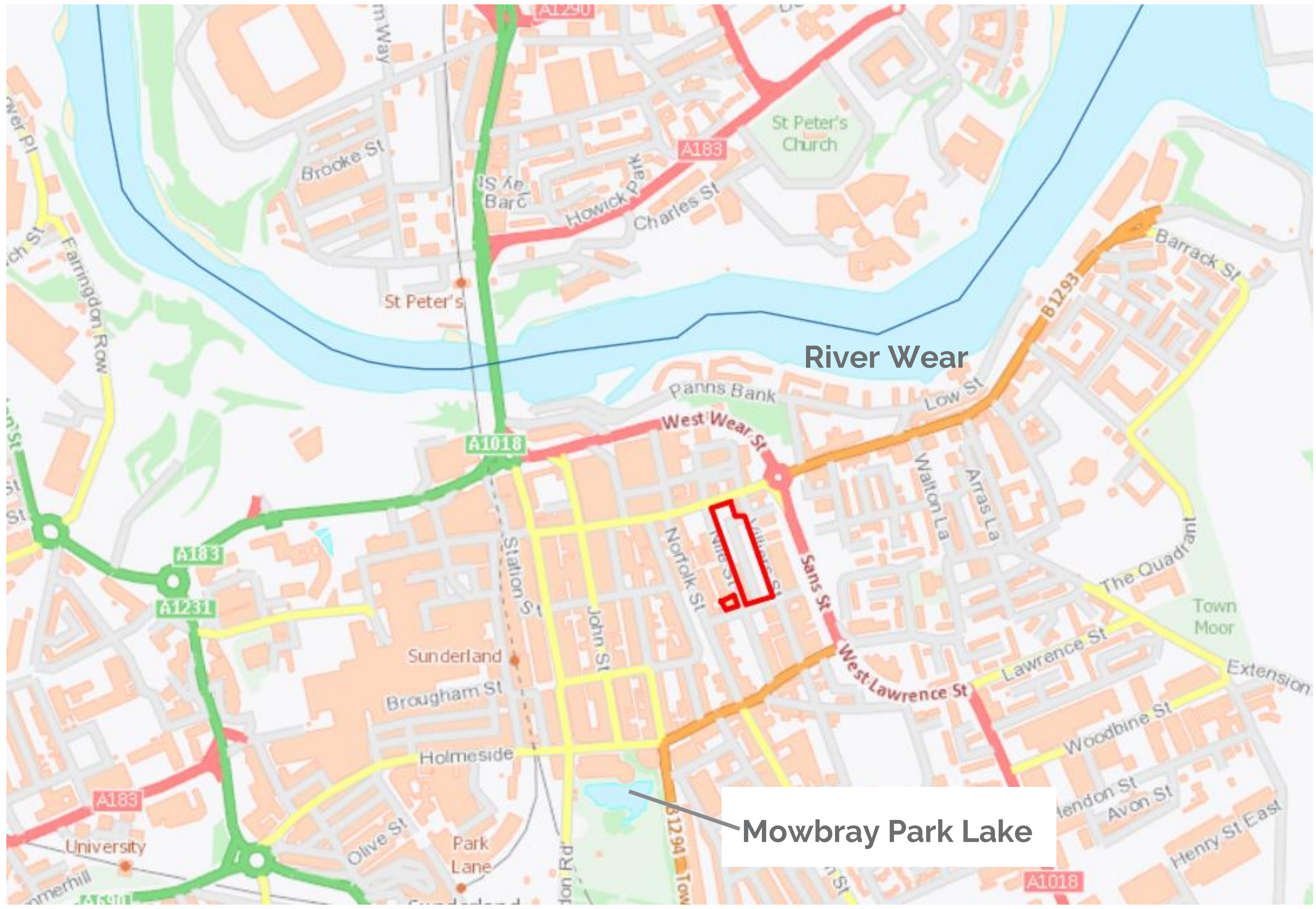



*Figure 2: EA Statutory main river map*

## 3.4 Existing Drainage

Records indicate there are several combined sewers owned by Northumbrian Water (NWL) running underneath the site. A 300mm diameter combined sewer runs from the centre of the site southwards following the path up to an intersecting chamber underneath Coronation Street.

Another 300mm diameter combined sewer runs from a capped end northwards until an intersection with another combined public sewer running from east to west alongside the south side of the carpark.

A 1350mm diameter concrete combined sewer lies beneath the southwest section of the site, running from southeast to northwest.

Figure 3 shows the location of the existing combined sewers around the site, as per the Northumbrian Water records (Available in Appendix A).


*Figure 3: Existing drainage infrastructure map from Northumbrian Water Records*

### 3.5 Geology

The British Geological Survey (BGS) data available online identifies the following geological strata beneath the site:

Superficial Deposits:

- Glaciofluvial Deposits, Devensian - Sand and gravel.
- Till, Devensian – Diamicton.

Bedrock Geology: Roker Formation – Dolostone.

The BGS geology viewer map suggests the bedrock geology is consistent across the site, whereas the superficial deposits vary throughout the site with Glaciofluvial Deposits, Devensian - Sand and gravel in south half of the site and Till, Devensian – Diamicton in the northern half of the site.

The BGS GeoIndex Onshore has historical records of several boreholes drilled in the vicinity of the site. The borehole logs generally show made ground underlain by a silty fine sand, stiff clay, and bedrock. The boreholes show no evidence of groundwater being encountered up to a depth of 10.7m. The logs are shown in Appendix C. Site investigation works will be undertaken to gather further understanding of the ground conditions below the site.

### 3.6 Hydrology

The Environmental Agency (EA) aquifer designations show the bedrock is a principal aquifer and the superficial drift is a secondary A aquifer. The site is an area of medium groundwater vulnerability but also associated with soluble rock risk and identified with 'local information'. The local information, shared by the LLFA (see correspondence in Appendix D) confirms the site lies within Source Protection Zone III (total catchment) and within zones of medium-high groundwater connectivity.

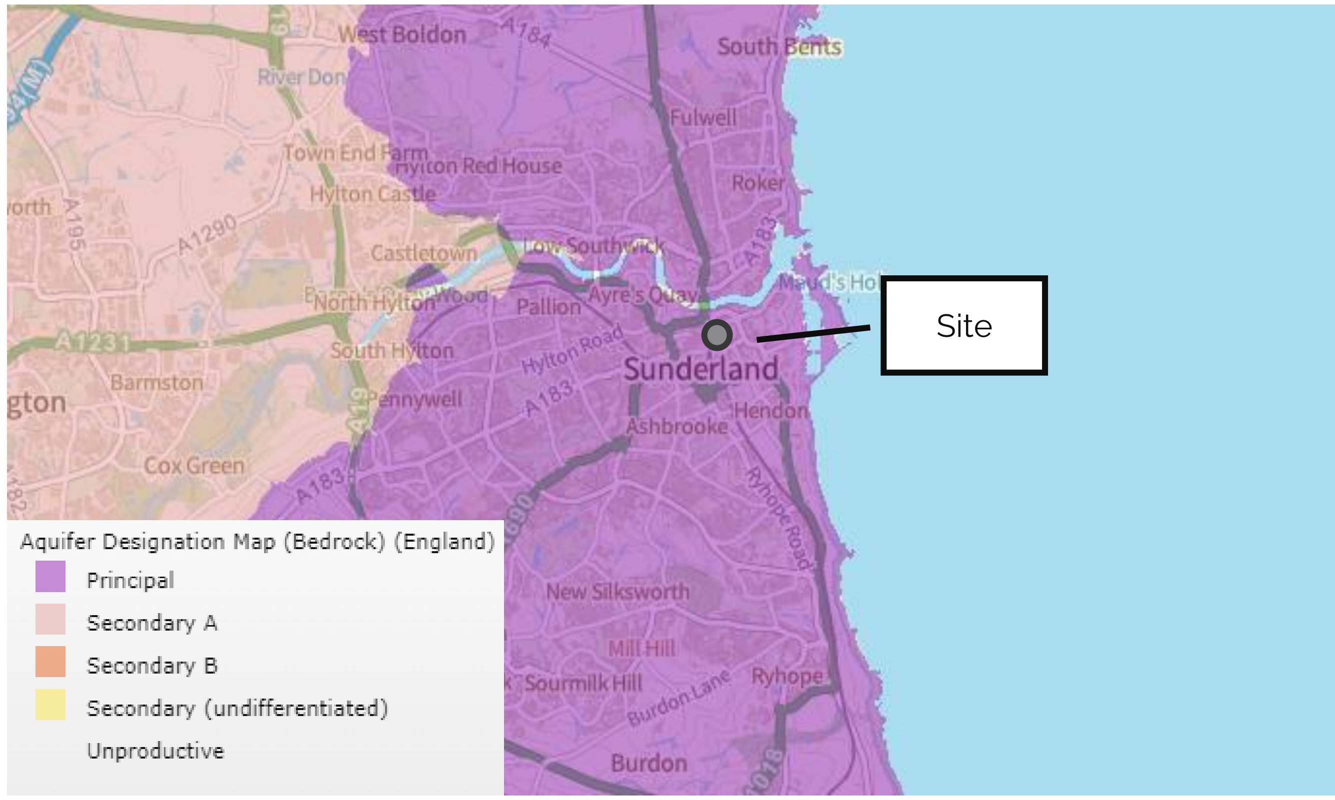



*Figure 5: The EA aquifer designation map for bedrock*


*Figure 4: The EA aquifer designation map for superficial drift*

# 4. Relevant Policy and Guidance

## 4.1 National Planning Policy Framework 2021 & Planning Practice Guidance 2022

*Flood Risk Categorisation*

The NPPF refers to the Flood Zones shown on the EA Flood Map for Planning (Rivers and Sea), and establishes the range of uses which are appropriate, or compatible, for each Flood Zone. Table 1, extracted from the Flood Risk and Coastal Change PPG (Table 1), summarises the Flood Zones.

*Table 1: Flood Zones*

| Flood Zone | Definition |
|---|---|
| Zone 1 Low probability | Land having a less than 1 in 1,000 (0.1%) annual probability of river or sea flooding. (Shown as 'clear' on the Flood Map for Planning – all land outside Zones 2, 3a and 3b) |
| Zone 2 Medium probability | Land having between a 1 in 100 and 1 in 1,000 (1% and 0.1%) annual probability of river flooding; or land having between a 1 in 200 and 1 in 1,000 (0.5% and 0.1%) annual probability of sea flooding. (Land shown in light blue on the Flood Map for Planning) |
| Zone 3a High probability | Land having a 1 in 100 (1%) or greater annual probability of river flooding; or Land having a 1 in 200 (0.5%) or greater annual probability of sea flooding. (Land shown in dark blue on the Flood Map for Planning) |
| Zone 3b Functional floodplain | This zone comprises land where water from rivers or the sea has to flow or be stored in times of flood. The identification of functional floodplain should take account of local circumstances and not be defined solely on rigid probability parameters. Functional floodplain will normally comprise:<br><br>• land having a 1 in 30 (3.3%) or greater annual probability of flooding, with any existing flood risk management infrastructure operating effectively; or<br><br>• land that is designed to flood (such as a flood attenuation scheme), even if it would only flood in more extreme events (such as 0.1% annual probability of flooding).<br><br>Local planning authorities should identify in their Strategic Flood Risk Assessments areas of functional floodplain and its boundaries accordingly, in agreement with the Environment Agency. (Not separately distinguished from Zone 3a on the Flood Map) |

The EA Flood Map for Planning (Figure 6) indicates the site is in Flood Zone 1.

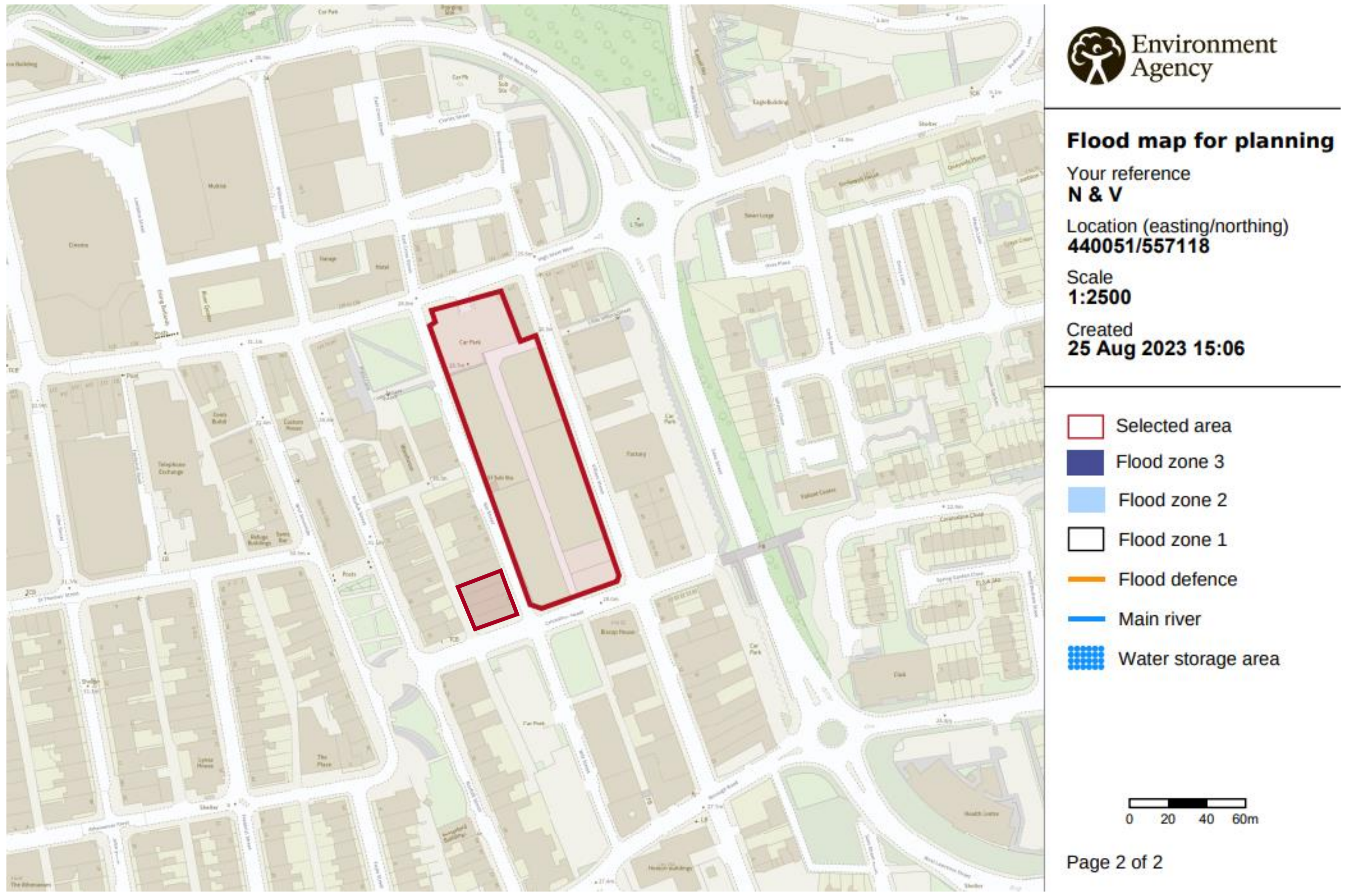



*Figure 6: The EA Flood Map for Planning for the Nile & Villiers site*

*Flood risk vulnerability and Flood Zone compatibility*

Annex 3 of the NPPF defines the type and nature of different development classifications in the context of their flood risk vulnerability. The information in Annex 3 was extracted and is presented in Table 2.

*Table 2: Flood risk vulnerability classification*

| Classification | Description |
|---|---|
| Essential infrastructure | • Essential transport infrastructure (including mass evacuation routes) which has to cross the area at risk.<br>• Essential utility infrastructure which has to be located in a flood risk area for operational reasons, including infrastructure for electricity supply including generation, storage and distribution systems; including electricity generating power stations, grid and primary substations storage; and water treatment works that need to remain operational in times of flood.<br>• Wind turbines.<br>• Solar farms. |

| Classification | Description |
|---|---|
| Highly vulnerable | • Police and ambulance stations; fire stations and command centres; telecommunications installations required to be operational during flooding.<br>• Emergency dispersal points.<br>• Basement dwellings.<br>• Caravans, mobile homes and park homes intended for permanent residential use.<br>• Installations requiring hazardous substances consent. (Where there is a demonstrable need to locate such installations for bulk storage of materials with port or other similar facilities, or such installations with energy infrastructure or carbon capture and storage installations, that require coastal or water-side locations, or need to be located in other high flood risk areas, in these instances the facilities should be classified as 'Essential Infrastructure'.) |
| More vulnerable | • Hospitals<br>• Residential institutions such as residential care homes, children's homes, social services homes, prisons, and hostels.<br>• Buildings used for dwelling houses, student halls of residence, drinking establishments, nightclubs, and hotels.<br>• Non–residential uses for health services, nurseries, and educational establishments.<br>• Landfill* and sites used for waste management facilities for hazardous waste.<br>• Sites used for holiday or short-let caravans and camping, subject to a specific warning and evacuation plan. |
| Less vulnerable | • Police, ambulance, and fire stations which are not required to be operational during flooding.<br>• Buildings used for shops; financial, professional, and other services; restaurants, cafes, and hot food takeaways; offices; general industry, storage, and distribution; non-residential institutions not included in the 'more vulnerable' class; and assembly and leisure.<br>• Land and buildings used for agriculture and forestry.<br>• Waste treatment (except landfill* and hazardous waste facilities).<br>• Minerals working and processing (except for sand and gravel working).<br>• Water treatment works which do not need to remain operational during times of flood.<br>• Sewage treatment works, if adequate measures to control pollution and manage sewage during flooding events are in place.<br>• Car parks. |

| Classification | Description |
|---|---|
| Water-compatible development | • Flood control infrastructure.<br>• Water transmission infrastructure and pumping stations.<br>• Sewage transmission infrastructure and pumping stations.<br>• Sand and gravel working.<br>• Docks, marinas, and wharves.<br>• Navigation facilities.<br>• Ministry of Defence installations.<br>• Ship building, repairing, and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location.<br>• Water-based recreation (excluding sleeping accommodation).<br>• Lifeguard and coastguard stations.<br>• Amenity open space, nature conservation and biodiversity, outdoor sports and recreation and essential facilities such as changing rooms.<br>• Essential ancillary sleeping or residential accommodation for staff required by uses in this category, subject to a specific warning and evacuation plan. |

The flood risk vulnerability and flood zone 'incompatibility', extracted from the PPG (flood risk and coastal change, Table 2) is presented below, in Table 3.

*Table 3: Flood risk vulnerability and flood zone 'incompatibility'*

| Flood Zones | Essential Infrastructure | Highly Vulnerable | More Vulnerable | Less Vulnerable | Water Compatible |
|---|---|---|---|---|---|
| Zone 1 | √ | √ | √ | √ | √ |
| Zone 2 | √ | Exception Test Required | √ | √ | √ |
| Zone 3a ǂ | Exception Test Required ǂ | x | Exception Test Required | √ | √ |
| Zone 3b (functional floodplain) * | Exception Test Required * | x | x | x | √ * |
| √ Exception Test is not required. | x Development should not be permitted. | | | | |

"ǂ" In Flood Zone 3a essential infrastructure should be designed and constructed to remain operational and safe in times of flood.

"*" In Flood Zone 3b (functional floodplain) essential infrastructure that has passed the Exception Test, and water-compatible uses, should be designed and constructed to:

- remain operational and safe for users in times of flood;
- result in no net loss of floodplain storage;
- not impede water flows and not increase flood risk elsewhere.

The proposals for the development of the site are likely to fall within more than one flood risk vulnerability category, summarised in Table 4 below.

*Table 4: Site specific flood risk vulnerability classification*

| Classification | Description |
|---|---|
| More vulnerable | Buildings used for dwelling houses, student halls of residence, drinking establishments, nightclubs, and hotels. |
| Less vulnerable | Buildings used for shops; financial, professional, and other services; restaurants, cafes, and hot food takeaways; offices; general industry, storage, and distribution; non-residential institutions not included in the 'more vulnerable' class; and assembly and leisure. |

'More vulnerable' and 'less vulnerable' development in Flood Zone 1 does not require an Exception Test.

### 4.2 Flood risk assessments: climate change allowances (EA, 2022)

The site lies within the Wear Management Catchment, as defined by the Department for Environment Food and Rural Affairs (Defra) Climate Change Allowances Map. Table 5 shows the anticipated increases in rainfall intensity over time, for this catchment, for the 3.3% and 1% annual exceedance rainfall events.

*Table 5: Irwell Management Catchment peak rainfall climate change allowances*

| 3.3% annual exceedance rainfall event | | |
|---|---|---|
| **Epoch** | **Central allowance** | **Upper end allowance** |
| 2050s | 20% | 35% |
| 2070s | 30% | 40% |
| **1% annual exceedance rainfall event** | | |
| 2050s | 25% | 40% |
| 2070s | 30% | 45% |

*Use '2050s' for development with a lifetime up 2060 and use the 2070s epoch for development with a lifetime between 2061 and 2125.

**Source: https://environment.data.gov.uk/hydrology/climate-change-allowances/rainfall

The EA guidance provides advice on using the peak rainfall intensity allowances to assess surface water flood risk, as quoted below:

*'Use the development lifetime guidance to work out the lifetime of your development. You should consider residential development to have a minimum lifetime of a 100 years.*

*Development with a lifetime beyond 2100:*

*This includes development proposed in applications or local plan allocations.*

*For flood risk assessments and strategic flood risk assessments assess the upper end allowances. You must do this for both the 1% and 3.3% annual exceedance probability events for the 2070s epoch (2061 to 2125).*

*Design your development so that for the upper end allowance in the 1% annual exceedance probability event:*

- *there is no increase in flood risk elsewhere.*
- *your development will be safe from surface water flooding.*

The proposed development includes residential and is therefore considered to have a minimum lifetime of 100 years, meaning the 2070s epoch applies. To comply with the previously stated guidance, the surface water drainage system will be designed based on a 45% climate change allowance to the 1% annual exceedance rainfall event and designed to ensure there is no increase in flood risk elsewhere and the development is safe from surface water flooding.

### 4.3 Sunderland City Council Core Strategy and Development Plan 2015 – 2033

*Policy WWE2 – Flood risk and coastal management*

1) To reduce flood risk and ensure appropriate coastal management, development:
   i) should follow the sequential approach to determining the suitability of land for development, directing new development to areas at the lowest risk of flooding and where necessary applying the exception test, as outlined in national planning policy;
   ii) will be required to demonstrate, where necessary, through an appropriate Flood Risk Assessment (FRA) that development will not increase flood risk on site or elsewhere, and if possible, reduce the risk of flooding;
   iii) will be required to include or contribute to flood mitigation, compensation and/or protection measures, where necessary, to manage flood risk associated with or caused by the development;
   iv) should comply with the Water Framework Directive by contributing to the Northumbria River Basin Management Plan;
   v) will maintain linear coastal flood defences north from Hendon Sea Wall to Seaburn, and managed coastal retreat on the Heritage Coast and north of Seaburn;
   vi) which would adversely affect the quantity of surface or groundwater flow or ability to abstract water must demonstrate that no significant adverse impact would occur, or mitigation can be put in place to minimise this impact; and
   vii) of additional river flood defences must demonstrate that the proposal represents the most sustainable response to a particular threat

*Policy WWE3 – Water Management*

Development must consider the effect on flood risk, on-site and off-site, commensurate with the scale and impact. Development must:

1. be accompanied by a Flood Risk Assessment (where appropriate), to demonstrate that the development, including the access, will be safe, without increasing or exacerbating flood risk elsewhere and where possible will reduce flood risk overall;

2. demonstrate that they pass the Sequential Test and if necessary the Exceptions Test in Flood Zones 2 and 3;
3. discharge at greenfield run-off rates for the 1 in 1 and 1 in 100 flood events plus the relevant climate change allowance for greenfield and brownfield sites in accordance with the latest Local Flood Risk Management Strategy;
4. incorporate a Sustainable Drainage System (SuDS) to manage surface water drainage. Where SuDS are provided, arrangements must be put in place for their whole life management and maintenance;
5. separate, minimise and control surface water run-off by discharging in the following order:
    i. to an infiltration or soak away system;
    ii. to a watercourse (open or closed);
    iii. to a surface water sewer.

    However, if sites are within 250m of a tidal estuary or the sea, surface water can be discharged directly;

6. ensure adequate protection where sites may be susceptible to over land flood flows (as shown in the Strategic Flood Risk Assessment) or lie within a Surface Water Risk Area (as shown on the Environment Agency flood maps);
7. incorporate allowance for climate change in accordance with the latest Environment Agency Guidance;
8. make developer contributions, where needed, to ensure that the drainage infrastructure can cope with the capacity needed to support proposed new development;
9. demonstrate control of the quality of surface water run-off during construction and for the lifetime of the development. For all developments the management of water should be an intrinsic part of the overall development; and
10. not have a detrimental impact on the city's water resources, including the Magnesian Limestone aquifer and its ground source protection zones. Development along the River Wear and coast should take account of the Northumbria River Basin Management Plan, to deliver continuing improvements in water quality.

***Policy WWE4 – Water Quality***

The quantity and quality of surface and groundwater bodies and quality of bathing water shall be protected and where possible enhanced in accordance with the Northumbria River Basin Management Plan.

1) Water quality assessments will be required for:
    i) any physical modifications to a watercourse; and
    ii) any development which could indirectly, adversely affect water bodies.
2) Development that discharges water into a watercourse will be required to incorporate appropriate water pollution control measures.
3) Development that incorporates infiltration based SuDS will be required to incorporate appropriate water pollution control measures.
4) Development adjacent to, over or in, a main river or ordinary watercourse should consider opportunities to improve the river environment and water quality by:
    i) naturalising watercourse channels;
    ii) improving the biodiversity and ecological connectivity of watercourses;
    iii) safeguarding and enlarging river buffers with appropriate habitat; and
    iv) mitigating diffuse agricultural and urban pollution.

## 5. Critical Drainage Areas

As shown in Figure 8, the Sunderland City Council SFRA identifies the region that the Nile and Villiers site is in as not a critical drainage area.

## 6. Source Protection Zones (SPZ)

The source protection zone map (Figure 7), shared by the LLFA (see Appendix D) shows the Nile and Villiers site is within Source Protection Zone III (total catchment).

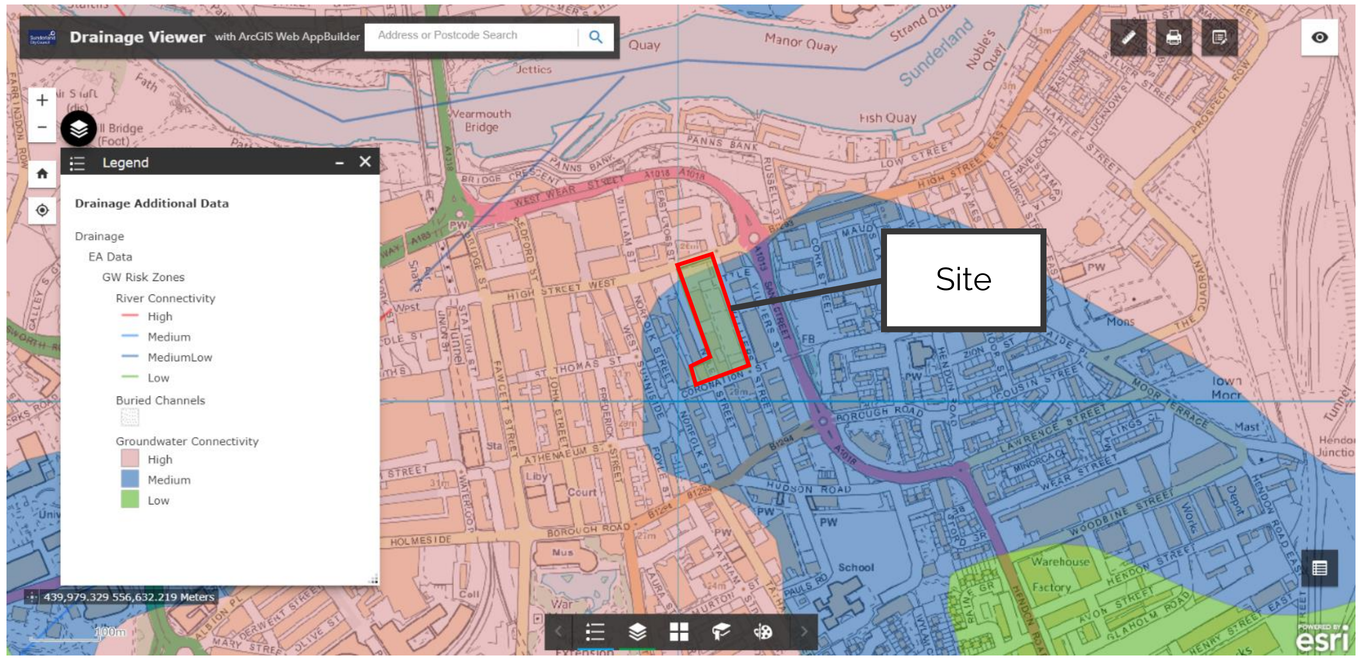



*Figure 7: Source Protection Zones*

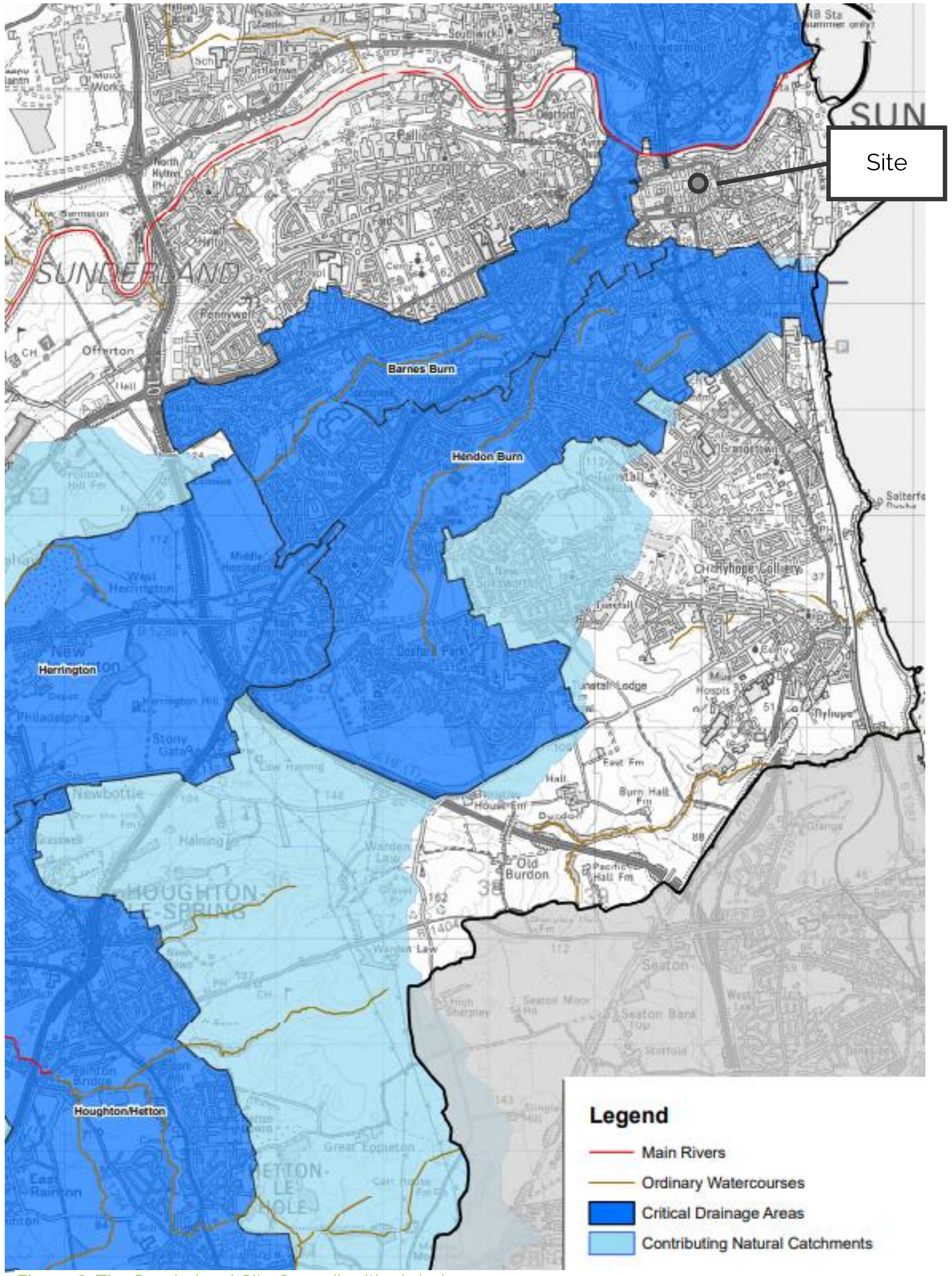



*Figure 8: The Sunderland City Council critical drainage area map*

# 7. Hydrological Assessment

## 7.1 Flooding History

There is no record of flooding within the Historic Flood Map published by the Environment Agency which has recorded major flood data since records began in 1946.

The LLFA has confirmed there have been no flood incidents recorded within the site or within 100m of the site.

## 7.2 Fluvial Flood Risk

The EA Flood Risk from Rivers or the Sea map (Figure 9) indicates the site is at very low risk from fluvial flooding, meaning there is less than 0.1% chance of flooding from the rivers or sea each year. The site is therefore considered to be at very low risk of fluvial flooding.

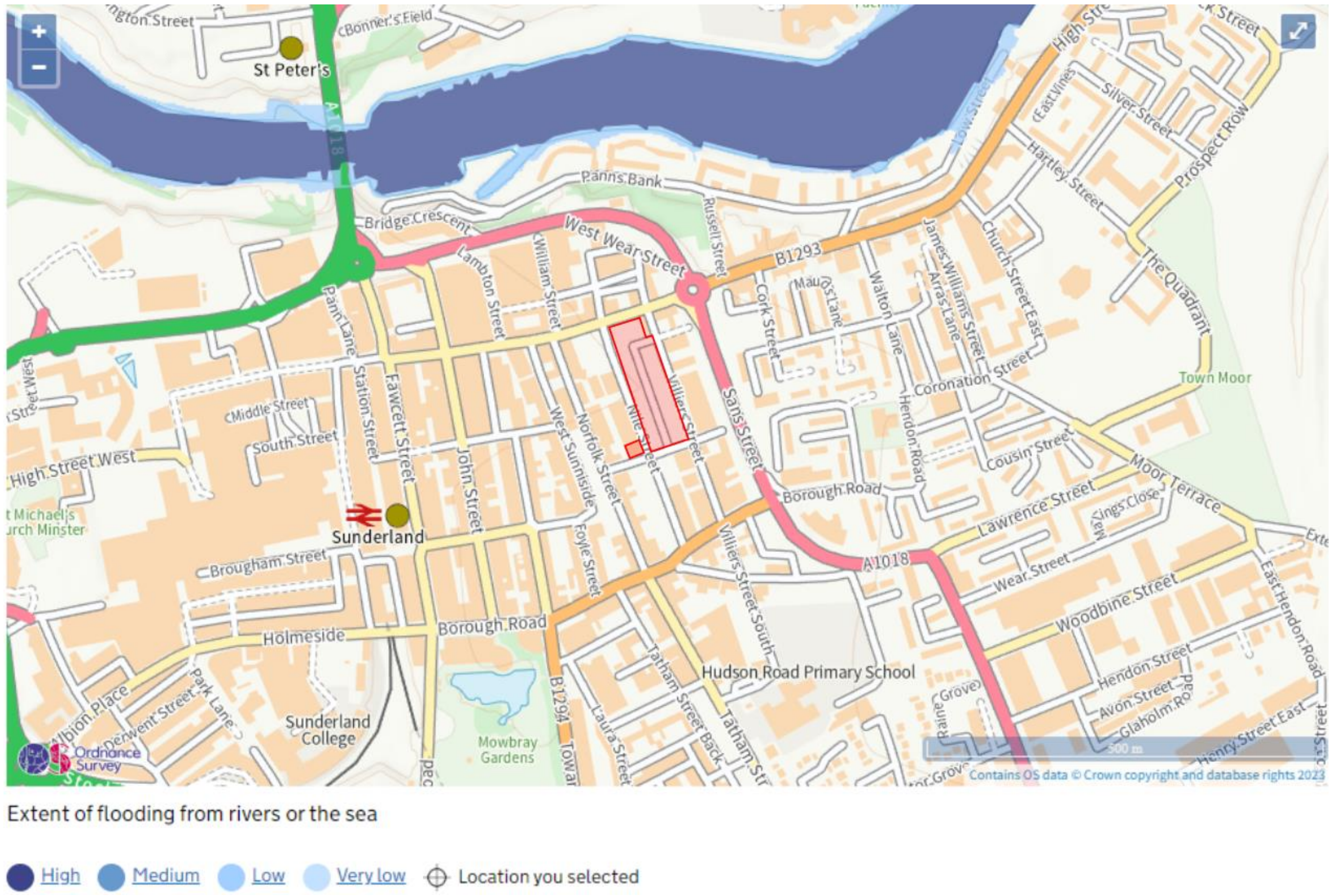



*Figure 9: The EA Flood Risk from Rivers or the Sea map*

## 7.3 Surface water flood risk

The EA flood risk from surface water map (Figure 10) shows that the site is at very low risk of flooding from surface water, meaning there is less than 0.1% chance of flooding from surface water each year.

At the northern boundary of the site, on High Street West, there is an area of low risk of surface water flooding., This is assumed to be a result of the converging northern and southern road catchments at High Street West, where the surface levels drop to ~27 – 28mAOD.

Temporary ponding of surface runoff in roads is to be expected after heavy rainfall, especially in localised low spots within the wider topography. The flood maps indicate the section of High Street West adjacent to the site as having a low risk of surface flooding below 300mm depth and show the area to be contained within the highway. Ground levels continue to fall steeply to the east along High Street West and as such, any build-up of surface water flows along the road channel without impacting or restricting access to the site.

Overall, the site is considered to be at very low risk of surface water flooding.

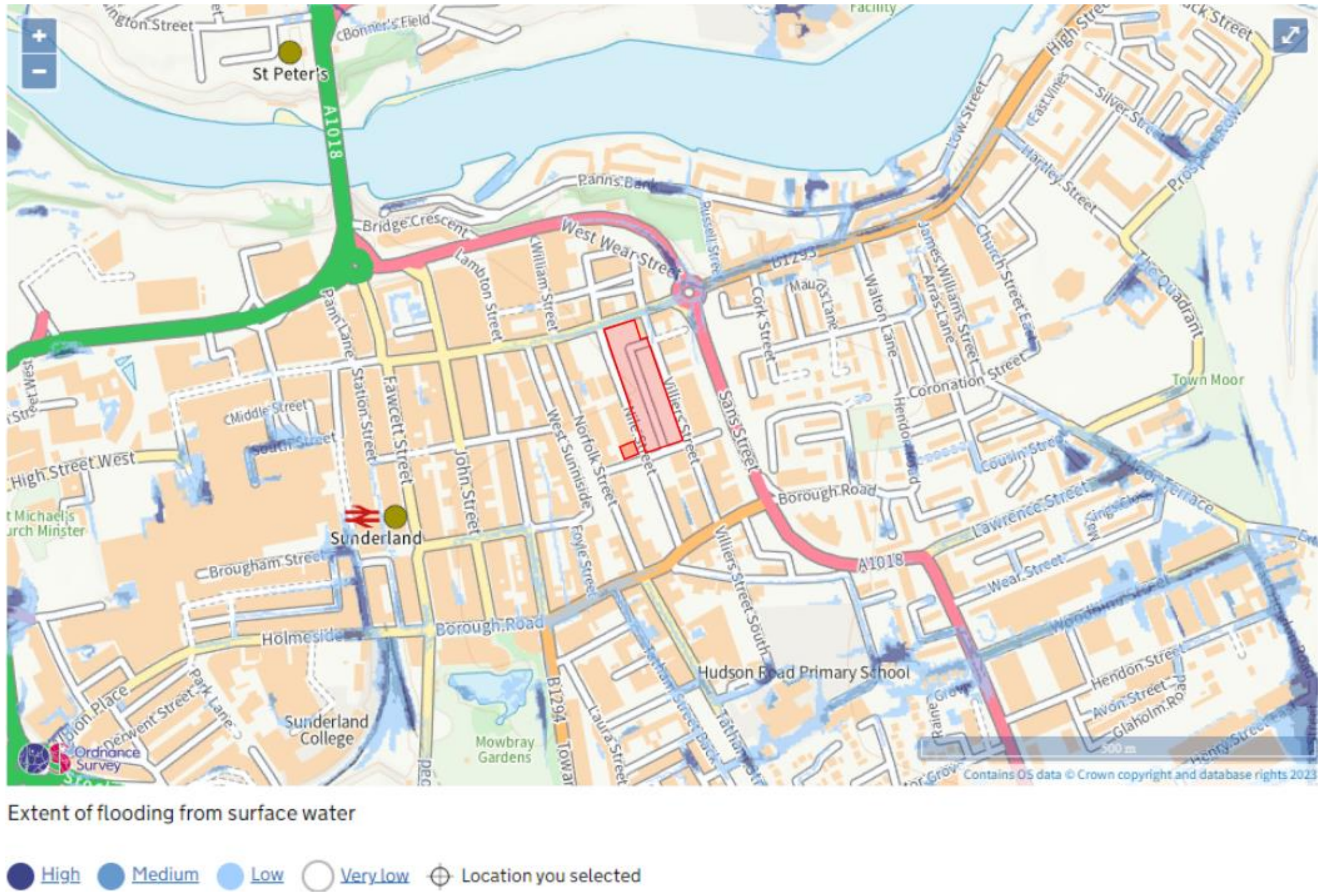



*Figure 10: The EA flood risk from surface water map*

## 7.4 Tidal Flood Risk

The site is located approximately 1.3km from the North Sea and sits approximately 30m above sea level. The site is considered to be at very low risk from tidal flooding.

## 7.5 Reservoir Flood Risk

The EA flood risk from reservoirs map (Figure 11) shows the site lies outside of the predicted maximum extent of flooding from reservoir failure and is therefore considered to be at no significant risk of flooding from reservoirs.

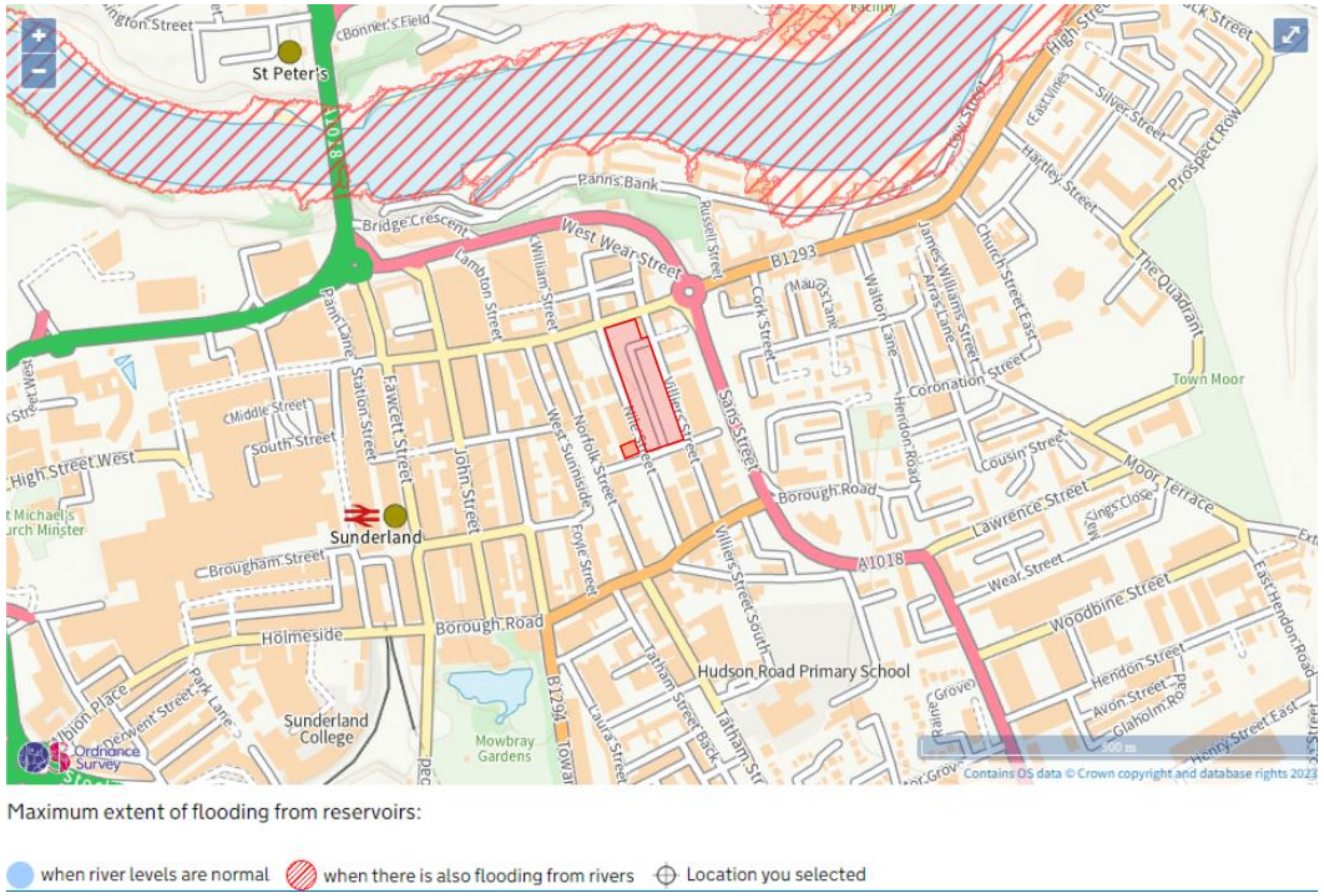



*Figure 11: The EA flood risk from reservoirs*

## 7.6 Groundwater Flood Risk

The Sunderland City Council (SCC) SFRA (2010) states 'There is not a significant risk of groundwater flooding in Sunderland but it should not be dismissed as a possibility and the FRA should consider the potential mechanisms that could affect the development site, as outlined in Volume II.' The Sunderland City Council SFRA (2017) states '…there are no known groundwater flooding problems [in the River Wear Catchment].'

The SCC SFRA also includes information on the risk of groundwater emergence. Based on the EA's national dataset, Areas Susceptible to Groundwater Flooding (AStGWF), the site has a less than 25% risk of groundwater emergence. The dataset is a low-resolution map based on hydrogeological conditions and does not consider site specific information.

From the BGS GeoIndex Onshore borehole logs, the presence of groundwater is not found in depths up to 10m.

The site is considered to have a very low risk of groundwater flooding.

## 7.7 Public sewer flooding, highway drainage flooding and infrastructure failure

The Lead Local Flood Authority (LLFA) for the Nile and Villiers site confirmed that there has been no record of flooding within 100m of the site.

Northumbrian Water (NWL), the water and sewerage service provider for Sunderland, have confirmed that there have been no flooding incidents due to hydraulic issues (e.g., capacity) within proximity to the site. Whilst NWL could confirm historic flooding events due to hydraulic issues, they hold no record of flooding due to infrastructure failure or blockages.

Flood maps from the SCC SFRA (2010) indicate two outstanding highway drainage problems nearby the site location. The LLFA have confirmed these dots have been placed in the incorrect location and can be ignored (refer to correspondence in Appendix D).

The site is therefore considered to have a very low risk of flooding from public sewers, highway drainage or infrastructure failure.

## 7.8 Summary of Flood Risk

A summary of the flood risk to the site is shown in Table 6, based on the evidence collated and assessment provided in section 7. Overall flood risk to the site is very low.

*Table 6: Summary of flood risk*

| Source of flooding | Risk to the site |
|---|---|
| River | Very low |
| Surface water | Very low |
| Sea | Very low |
| Reservoir | Insignificant |
| Groundwater | Very low |
| Infrastructure | Very low |

## 8. Proposed Surface Water Drainage Strategy

### 8.1 Point of Discharge

The NPPF PPG – Flood risk and coastal change, specifies the following hierarchy of drainage options for the discharge of surface water:

1. *into the ground (infiltration);*
2. *to a surface water body;*
3. *to a surface water sewer, highway drain, or another drainage system;*
4. *to a combined sewer."*

An appraisal of each option of the discharge hierarchy follows.

*Infiltration based systems.*

The LLFA has confirmed that due to the site being located within a Source Protection Zone and area of medium-high groundwater connectivity, infiltration will not be permitted, and all proposed SuDS features shall be lined. Refer to the LLFA correspondence in Appendix D.

*Surface waterbody*

The closest waterbody to the site is the River Wear, which is located approximately 245m north of the site, as shown in section 3.3. As the site is located in a dense urban environment, requisitioning a new sewer system to the river would require crossing of both public land and several privately held third party sites. There is a large level difference of approximately 20m between the site and river so any sewer route would need to travel over 600m to avoid existing retaining walls (along Panns Bank) and would also need to cross the A1018.

As such, connecting to a water body is not feasible.

*Surface water sewer*

As shown in the Northumbrian Water (NWL) sewer records in Appendix A, there are no surface water sewers located in the vicinity of the site.

*Combined sewer*

A connection to the public combined sewer is required to dispose of surface water runoff from the site.

New connections will be made via existing manholes and re-using existing outfall pipes to the combined sewer network, where feasible. A total of 4no. drainage outfalls are required, as indicated in Figure 12. A pre-planning enquiry has been submitted to NWL to confirm their sewer network has the capacity to receive flows from the development.


*Figure 12: Indicative outfall locations*

*Discharge location summary*

*Table 7: Summary of Point of Discharge Suitability*

| Point of discharge | Suitability |
|---|---|
| Ground | x |
| Waterbody | x |
| Surface water sewer | x |
| Combined sewer | √ |
| √ suitable × unsuitable | |

## 8.2 Site areas

The overall site area is approximately 0.810ha.

For the existing site, 0.295ha is impermeable (the road, car parks and 19-21 Nile Street) and 0.515ha is laid to lawn.

The proposed site has a positively drained catchment area of approximately 0.70ha, which comprises the new building rooftops, external hardstanding areas and the proposed SuDS features (which are positively drained). The remaining 0.11ha is free-draining soft landscaping/private gardens.

The site areas are summarised in Table 8: Site areas

*Table 8: Site areas*

| *Site Areas* | | | |
|---|---|---|---|
| Site | Permeable | Impermeable | Total |
| Existing | 0.515ha | 0.295ha | 0.810ha |
| Proposed | 0.100ha | 0.700ha | |

## 8.3 Existing run-off rates

Existing run-off rates for the site have been estimated using Causeway Flow+ software.

The calculations of brownfield run-off, from the existing impermeable areas, are based on the Modified Rational Method (MRM), outlined below:

Q = (2.78 CV Cr I A)

where

Cr is the routing coefficient = 1.3

Cv is the runoff coefficient = 1

I is the average rainfall intensity (mm/hr) for the storm of duration equal to the time of concentration for the network and is generated within the software.

A is impermeable area in ha.

2.78 is a conversion factor.

The existing road and car parks discharge unrestricted and directly to external drains, so a time of concentration (for the network) of 15 minutes was used for the brownfield calculations. For the 15 minute 1 in 1 year storm event, the average rainfall intensity, I = 23.8mm/hr.

The calculations for the existing greenfield run-off are based on the FEH method using the Hydrology of Soil Type (HOST) value for the site, which is 24, as stated within the Soil Site Report from Cranfield University (see Appendix E).

The existing run-off rates are summarised in Table 9. The Causeway Flow+ outputs are available in Appendix F.

*Table 9: Existing Runoff Rates*

| **Existing runoff rates** | | | | |
|---|---|---|---|---|
| Area (ha) | Brownfield/greenfield | 1 in 1-year event | 1 in 30-year event | 1 in 100-year event |
| 0.295 | Brownfield | 28.6 l/s | 70.0 l/s | 90.3 l/s |
| 0.515 | Greenfield | 1.5 l/s | 3.3 l/s | 4.3 l/s |
| 0.81 | Combined | **30.1 l/s** | **73.3 l/s** | **94.6 l/s** |

## 8.4 Surface Water Rates, Attenuation & Sustainable Drainage Systems (SuDS)

### *SuDS and attenuation*

Externally, the SuDS features proposed include rainwater butts, linear rain gardens to the front and rear of the terraces, permeable paving, two soft landscaped SuDS amenity basins within the communal gardens and one urban SuDS basin within the northern courtyard.

Much of the attenuation for the site is provided within free-from-fines aggregate (with 30% voids) beneath the permeable paving, rain gardens and SuDS basins, as well as geo-cellular below ground storage. During heavier rainfall events the network can surcharge, with additional attenuation volumes being provided above, within the SuDS basins.

As the basins are also designed for amenity, side slopes are limited to 1 in 5 and a low flow channel is provided to contain flows from the 1 in 1 year storm event. The SuDS amenity basins are 0.5m deep and the urban SuDS basin is 0.65m deep. All basins are designed with 150mm freeboard and a max water level 300mm below adjacent finished floor levels.

Overflows from the raingardens will be provided in the form of either gullies to the underdrain or surface overflows to the adjacent SuDS basins.

The different SuDS proposed for the site are illustrated in Figure 13 and a breakdown of the attenuation volumes is included in Table 10. Additional detail is provided on the Surface Water Drainage Layout plan in Appendix G and the Landscape Masterplan in Appendix K. Some of the sketches produced during the development process for the SuDS proposals are included within Appendix L.

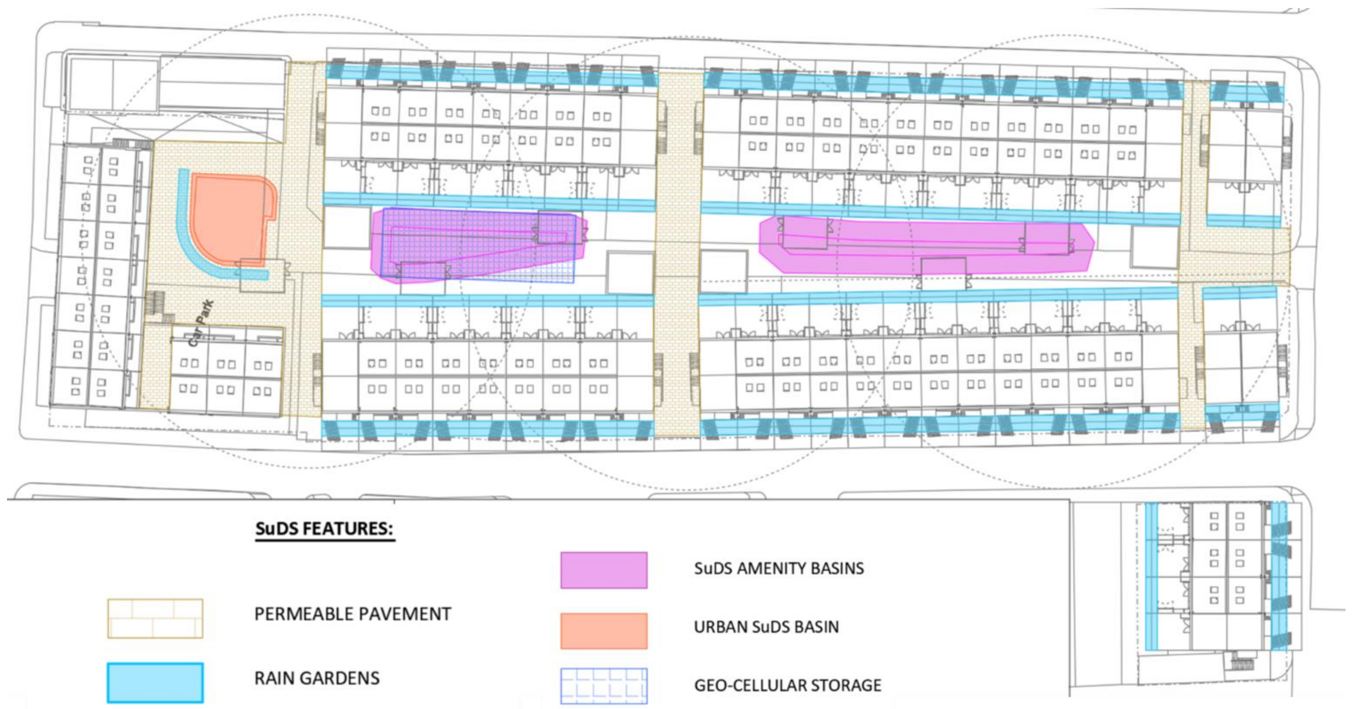



*Figure 13: SuDS features*

*Table 10: Breakdown of attenuation volumes*

| SuDS feature | Above ground attenuation | | | Below ground attenuation | | | | Total attenuation volume (m³) |
|---|---|---|---|---|---|---|---|---|
| | **Depth excl. freeboard (m)** | **Area (m²)** | **Volume excl. freeboard (m³)** | **Depth (m)** | **Voids %** | **Area (m²)** | **Volume (m³)** | |
| Rain gardens | 0.15-0.2 | 855 | Not designed for surcharge | 0.3 | 30 | 855 | 77 | 77 |
| SuDS Basins (soft) | 0.35 | 274 | 96 | 0.3 | 30 | 72 | 6.5 | 102.5 |
| SuDS Basin (urban) | 0.5 | 98 | 49 | 0.3 | 30 | 100 | 9 | 58 |
| Permeable paving | n/a | n/a | n/a | 0.3 | 30 | 1144 | 103 | 103 |
| Geocellular storage | n/a | n/a | n/a | 1.2 | 95 | 229 | 261 | 261 |
| | | | | | | | **Total volume** | **601.5** |

### *Water quantity & discharge*

Surface water discharge from the site is restricted targeting the QBar greenfield runoff rate, which is calculated as 2.74 l/s as shown in Appendix H and summarised in Table 11.

*Table 11: Greenfield runoff rates*

| Greenfield runoff rate (l/s) | | | |
|---|---|---|---|
| 1 in 1-year event | 1 in 30-year event | 1 in 100-year event | QBar |
| 2.35 l/s | 4.79 l/s | 5.69 l/s | 2.74 l/s |

In line with the NE LLFA Sustainable Drainage Local Standards, flows will be restricted at the 4no. outfall locations utilising a 50mm orifice flow control (refer to correspondence with the LLFA in Appendix D). This means the target peak discharge rate of 2.74 l/s (QBar) is not achievable, however, a significant betterment to existing runoff has been achieved as outlined in Table 12.

*Table 12: Runoff betterment achieved for each storm event.*

| | Surface water discharge rate (l/s) | | |
|---|---|---|---|
| | 1 in 1-year event | 1 in 30-year event | 1 in 100-year event +45% CC* |
| Existing site | 30.1 l/s | 73.3 l/s | 94.6 l/s |
| Proposed site | 9.3 l/s | 13.7 l/s | 21.7 l/s |
| Betterment on existing | 69% | 81% | 77% |

*No climate change allowance within the existing runoff.

As shown, the surface water discharge rates from the proposed site represent a 69% betterment in the 1 in 1-year event, 81% for the 1 in 30-year event and 77% betterment for the 1 in 100-year event plus 45% climate change.

A pre-planning enquiry has been submitted to Northumbrian Water relating to the proposed discharge and their response is awaited.

Approximately 600m³ of attenuation is designed to accommodate the 1 in 100-year plus 45% climate change rainfall event. 10% additional allowance has been added to the hydraulic model for urban creep. The hydraulic calculations, developed using Causeway Flow software, can be viewed in Appendix I.

### *Water Quality*

The CIRIA SuDS Manual provides a simple index approach to design drainage systems that offer an appropriate level of pollution risk management. Step 1 is to allocate suitable pollution hazard indices for the proposed land use. The pollution hazard indices applicable to the site are shown in Table 13.

*Table 13: CIRIA Pollution hazard indices for different land use classifications*

| Land use | Pollution hazard level | Total suspended solids (TSS) | Metals | Hydro-carbons |
|---|---|---|---|---|
| Residential roofs | Very Low | 0.2 | 0.2 | 0.05 |
| Individual property driveways, residential car parks, low traffic roads, car parks with infrequent change | Low | 0.5 | 0.4 | 0.4 |

Step 2 is to determine SuDS pollution mitigation indices. It is proposed to have permeable paving on the new access road and car park. Table 14 provides the mitigation indices applicable to the site.

*Table 14: CIRIA indicative SuDS mitigation indices for discharge to surface waters*

| Type of SuDS component | Mitigation indices | | |
|---|---|---|---|
| | Total suspended solids (TSS) | Metals | Hydro-carbons |
| Permeable Pavement | 0.7 | 0.6 | 0.7 |
| Detention Basin | 0.5 | 0.5 | 0.6 |
| Bioretention system | 0.8 | 0.8 | 0.8 |

As stated within the SuDS Manual, to provide adequate treatment, the SuDS components should have a total pollution mitigation index (for each contaminant type) that equals or exceeds the pollution hazard index (for each contaminant type).

All sub-catchments within the site will discharge to a SuDS feature. Every SuDS feature proposed will, on its own, fulfil the criteria shown below (see values presented in Table 13 and Table 14) and will be deemed sufficient to manage pollution risk:

Total SuDS mitigation index ≥ Pollution hazard index

It is to be noted that permeable paving provides pollution control and has been shown to reduce concentrations of contaminants such as oil, heavy metals, and sediments. Water quality treatment is provided to the surface water runoff through the following methods as detailed in the CIRIA 753 SuDS manual (CIRIA, 2015):

- Filtration – silt and attached pollutants become trapped within the top 30mm of the jointing material between blocks or porous surfacing i.e., asphalt, resin bound gravel, reinforced grass paving.
- Biodegradation – chemical dissolution of organic contaminants such as oil, petrol and diesel by bacteria, fungi or other biological means within the pavement layers.
- Adsorption – adhesion of contaminant particles to sand and gravel material surfaces within the pavement build-up. Dependent on factors such as aggregate type, structure, texture and moisture content.
- Settlement – retention of solid contaminants.

Furthermore, a geotextile membrane that encourage the growth of a microbic biofilm that degrades hydrocarbons (oil) will be incorporated within the construction build-up.

Bioretention systems provide water quality treatment to the surface water runoff through the following methods:

- Filtration – surface vegetation and groundcover trap sediment and associated pollutants. Fine particulates and contaminates removed by infiltration through the underlying filter medium layers.
- Sorption – dissolved pollutions removed by sorption of pollutants to the filter medium.

Detention basins reduce the contaminant load via volumetric control by retaining runoff from small events on site. They treat residual runoff through gravitational settling of particulate pollutants.

### 8.5 Sustainable Drainage Systems (SuDS) & water quality

The SuDS Manual CIRIA report C753 states that 'surface water run-off should be managed for maximum benefit.' The types of benefits that can be achieved by Sustainable Drainage Systems (SuDS) can be put into four categories, the four pillars of SuDS: water quantity, water quality, amenity, and biodiversity. Table 15 presents what benefits are likely to be provided by different SuDS features.

*Table 15: SuDS Likely Benefits*

| | SuDS Feature | Water quantity | Water quality | Amenity | Biodiversity |
|---|---|---|---|---|---|
| **Most Benefits** | Living roofs | √ | √ | √ | √ |
| ↑ | Infiltrations systems | √ | √ | √ | √ |
| | Dry planted features – Swales, bio retentions areas, trees, detention basins | √ | √ | √ | √ |
| | Ponds and wetlands | √ | √ | √ | √ |
| | Pervious & reservoir pavements | √ | √ | | |
| | Filter strips | √ | √ | | |
| | Filter drains | √ | √ | | |
| ↓ | Proprietary treatment systems | | √ | | |
| **Least Benefits** | Attenuation storage tanks | √ | | | |

Table 16 shows what SuDS techniques are proposed to manage surface water on-site. These features are being designed in collaboration with the design team to control water quantity, improve water quality, provide amenity, and promote biodiversity.

*Table 16 Summary of SuDS Techniques Proposed*

| SuDS Technique | Proposed? | Comment |
|---|---|---|
| Living roofs | N | Not considered suitable for this project. |
| Infiltration systems | N | The LLFA has advised infiltration is not permitted due to the groundwater connectivity and Source Protection Status of the site. |
| Dry planted features | Y | SuDS amenity basins and rain gardens. |
| Open water features | N | There are no suitable external areas for open water features as these spaces are used for the basins with storage beneath and hence need to be free draining. |
| Pervious & reservoir pavements | Y | Pervious and reservoir pavements are proposed for the external hardstanding areas. |
| Attenuation storage tanks | Y | Attenuation tank beneath northern SuDS basin. |

## 9. SuDS management & maintenance

### 9.1 SuDS – Normal function

SuDS generally mimic the natural drainage patterns of the undeveloped site allowing infiltration into the ground/attenuation, improving water quality and controlling outflow rates from the development. This reduces the impact and risk of flooding on downstream developments alongside providing additional benefits such as pollution control, increasing biodiversity and providing water-based amenity.

The sustainable drainage systems proposed for the site are as listed below:

- SuDS amenity basins;
- Urban basin;
- Permeable pavement;
- Rain Gardens;
- Water butts (rainwater harvesting).

In short, these drainage features will provide:

- a platform to capture surface water,
- a medium to attenuate, filter and treat surface water,
- and a means of conveying surface water.

### 9.2 Operation & maintenance requirements

The maintenance regime of the SuDS on site can be divided into three categories: regular maintenance, occasional tasks and remedial works. The frequency of regular maintenance will usually be monthly, the occasional tasks and remedial works should be conducted as required. Specific maintenance needs of the SuDS should be monitored, and maintenance schedules adjusted to suit requirements.

Appendix J contains a schedule providing guidance on the type of operational and maintenance requirements that may be appropriate, based on the CIRIA C753 SuDS Manual.

The activities listed are generic to the relative SuDS types and represent the minimum maintenance and inspection requirements, however additional tasks or varied maintenance frequency may be instructed by the maintenance company as required.

All those responsible for maintenance should follow the relevant Health and Safety legislation for all the activities listed including lone working, if relevant, and risk assessments should always be undertaken.

Inspection checks shall be carried out by a qualified and competent person, at the minimum intervals listed within the schedules and the appropriate work carried out.

Any parties involved with the disposal of any waste materials from the underground drainage system should hold appropriate management licenses to undertake any such activities. Disposal of any site materials is required to be made in accordance with current legislation and guidance.

The maintenance strategy for specific SuDS proposed at the site will be dependent upon the products used within the installation of the systems and is therefore subject to manufacturer's guidance.

### 9.3 Construction phase drainage measures & prohibited activities

The below measures should be implemented by the principal contractor during the construction phase to ensure the protection of drainage systems and management of runoff and pollutants during the construction phase:

- Installation and protection of the geo-cellular storage tanks in accordance with the manufacturer's specifications.
- The installation of free-draining aggregate subbase for permeable pavements shall be immediately followed by the installation of a geotextile separating membrane and, where feasible, the laying course and finished surfacing.
- The storage of materials directly onto permeable pavements shall be prohibited. Where storage of materials is unavoidable an impermeable separating membrane shall be laid onto the pavement surface first to prevent silting or contamination of the permeable pavement layers.
- Any fuel, substances or generators that pose a risk of pollution shall be properly stored within containment bunds.

Additional measures may be required and shall be agreed with the contractor prior to mobilisation on site.

### 9.4 End of life maintenance

As part of their normal function, many SuDS features are intended to act as a repository for potential pollutants such as sediment, hydrocarbons and heavy metals, thus improving the water quality of run-off. Certain pollutants, such as hydrocarbons, can be broken down via biodegradation. However, other pollutants, namely the particulate or sediment type, such as heavy metals, remain trapped within elements of the sustainable drainage feature.

Current evidence does not conclude to what extent pollution entrapment within SuDS will occur or the likely status of materials within their construction at the time of their disposal. For these reasons, it is proposed that at end-of-life, all SuDS are disposed of in accordance with the relevant rules, regulations, and available guidance at the time. If required, at redevelopment stage, consultation with the Environment Agency should be sought and testing of materials and ground, for contamination, should be carried out.

## 10. Proposed Foul Drainage Strategy

Foul water collected from the development will be discharged to the existing NWL combined sewer network running within and surrounding the site. A pre-planning enquiry has been submitted to NWL to confirm their network has the capacity for the anticipated peak foul water discharges.

## 11. Existing drainage alterations

There are several existing combined water sewers running through the site. As part of the proposed development some of these sewers, which are redundant, will be removed. Sewers serving offsite catchments will be retained where feasible or diverted otherwise. An application will be made to NWL at the appropriate time.

The existing sewer records from NWL are shown in Appendix A.

## 12. Conclusions

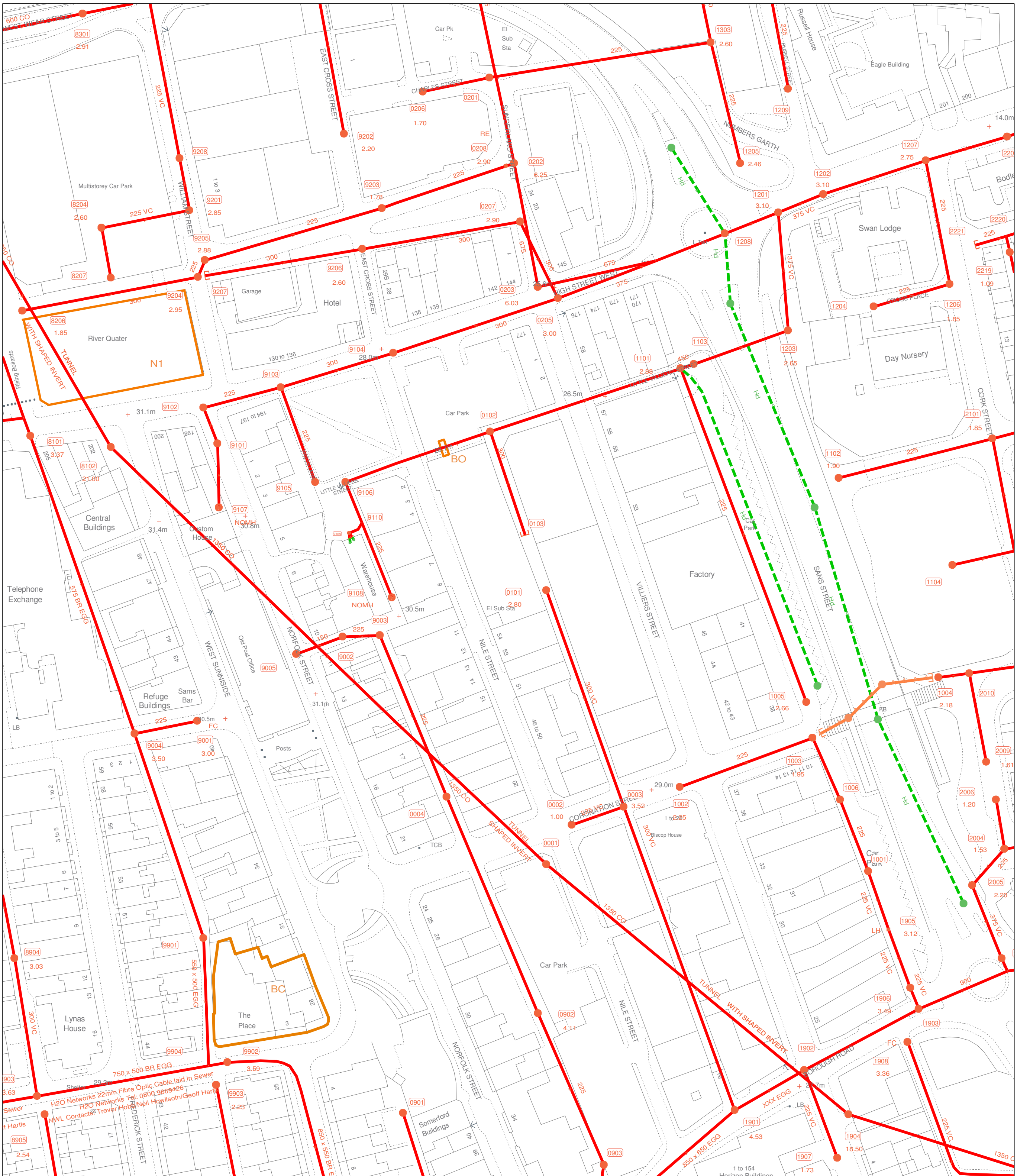
The site is located in Flood Zone 1 and the proposed development is appropriate for this flood zone.

The FRA has also demonstrated that the proposed development is at very low or insignificant risk from flooding from all sources. The proposed surface water drainage strategy reduces the flood risk from surface water to the site and downstream areas by significantly reducing runoff from the site and the discharge rate to the public sewer.

In line with national and local guidance/policy, surface water will be managed using a variety of sustainable drainage systems, including rain gardens, water butts, basins and permeable pavements, providing a significant improvement to the quality of runoff from site as well as amenity, biodiversity and other benefits.

The SuDS features are providing a total of 601.5m$^3$ of effective storage and restricting the peak discharge rate to 21.7 l/s for the 1-in-100-year + 45% CC event, yielding a 77% betterment on the existing surface water discharge rates. The required attenuation volume has been calculated using the Causeway Flow software, to ensure there is no flooding to habitable spaces or escape routes for up to the 1 in 100-year storm event +45% allowance.

## Appendix A: Northumbrian Water (NWL) Sewer Records




| NWL Responsibility | | Private/Non NWL | | Proposed | |
|---|---|---|---|---|---|
| Combined | | Combined | | Combined | |
| Foul | | Foul | | Foul | |
| Surface | | Surface | | Surface | |
| Treated Eff | | Treated Eff | | | |
| Untreated Eff | | Trade Eff | | | |
| Overflow | | Watercourse | | | |

**Annotations**

- Direction of flow
- Backdrop
- Abandoned
- Rising Main

**Symbols**

- Chambers
- Inlet/Outlet
- STW Treatment Works
- Pumping Station
- Capped End
- Balancing Pond
- Termination Node
- Rodding Eye
- Unknown End
- Attribute Change
- Air Valve
- Property Connection
- Lamp Hole
- Hatchbox
- Dual Usage Chamber

NORTHUMBRIAN WATER *living water*

User : DAWSJ1

Date : 14/12/2020

Title : 0000

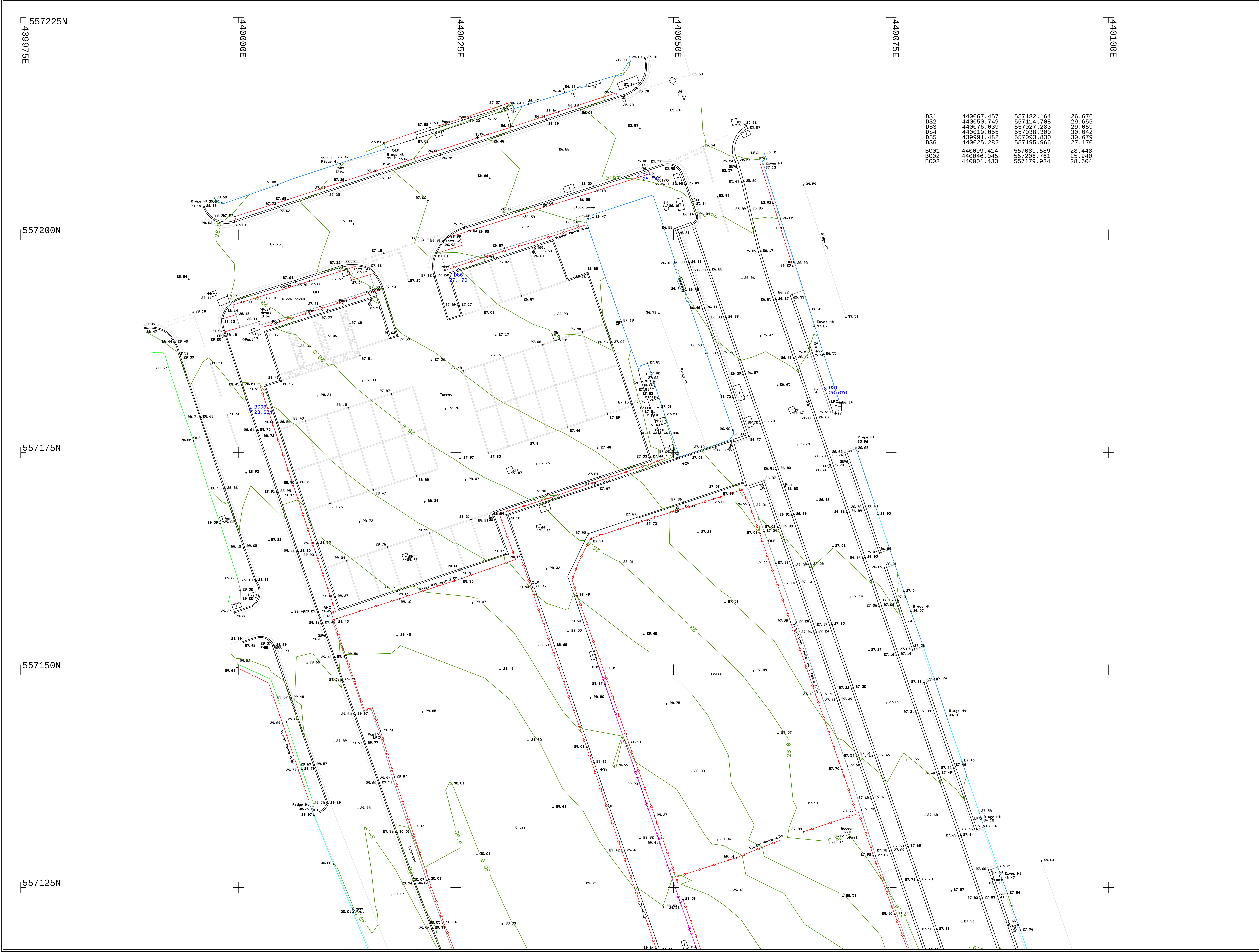
Centre Point : 440040,557110

Map Sheet : NZ4057SW


The information shown on this plan should be regarded as approximate and is intended for guidance only. No Liability of any kind whatsoever is accepted by Northumbrian Water, it's servants or agents for any omission. The actual position of any water mains or sewers shown on the plan must be established by taking trial holes in all cases. In the case of water mains Northumbrian Water must be given two working days notice of their intention to excavate trial holes. With effect from 1 October 2011, private lateral drains and sewers automatically transferred to Northumbrian Water under a scheme made by the Secretary of State pursuant to section 105A Water Industry Act 1991. These former private drains and sewers together with existing private connections may not be shown but their presence should be anticipated. WARNING...Where indicated on the plan there could be abandoned asbestos cement materials or shards of pipe. If excavating in the vicinity of these abandoned asbestos cement materials, the appropriate Health & Safety precautions should be taken. Northumbrian Water accepts no liability in respect of claims, costs, losses or other liabilities which arise as the result of the presence of the pipes or any failure to take adequate precautions.
Emergency Telephone Number: 0345 717 1100

20 m

## Appendix B: Topographical Survey




| | | | |
|---|---|---|---|
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| DS2 | 440050.749 | 557114.708 | 29.655 |
| DS3 | 440076.039 | 557027.283 | 29.059 |
| DS4 | 440019.055 | 557038.300 | 30.042 |
| DS5 | 439991.482 | 557093.830 | 30.679 |
| DS6 | 440025.282 | 557195.966 | 27.170 |
| BC01 | 440099.414 | 557089.589 | 28.448 |
| BC02 | 440046.045 | 557206.761 | 25.940 |
| BC03 | 440001.433 | 557179.934 | 28.604 |

## Legend

Boundary Type and Description

| | |
|---|---|
| C/B | Close Board |
| C/L | Chain Link |
| FE | Misc. |
| K/R | Knee Rail |
| O/B | Open Board |
| Pal | Palisade |
| M/R | Metal Railings |
| Pick | Picket |
| P/R | Post & Rail |
| P/W | Post & Wire |
| W/M | Wire Mesh |
| Brick | Brick Wall |
| Brick Ret. | Brick Retaining Wall |
| Stone | Stone Wall |
| Stone Ret. | Stone Retaining Wall |
| Block | Block Wall |
| Misc | Misc. Wall |
| | Gate |

Vegetation

- Hedge
- Edge of Hedge
- Edge of Canopy
- Tree and Trunk
- Stump
- Bush
- Verge

General Utility Linestyles

| | |
|---|---|
| CD | Drainage Combined |
| FD | Drainage Foul |
| SD | Drainage Surface |
| UD | Drainage Unidentified |
| O/C | O/Head Combined |
| O/E | O/Head Electric |
| | O/Head Lines |
| O/T | O/Head Telecom |

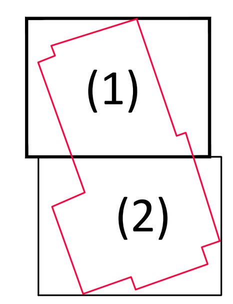
General Survey Abbreviations

| | | | |
|---|---|---|---|
| AV | Air Valve | GV | Gas Valve |
| BH | Borehole Collar | HP | Hand Pit |
| BX | Box (General) | IBO | Illuminated Bollard |
| BX/E | Box (Elec) | IC | Inspection Cover |
| BX/G | Box (Gas) | IL | Invert Level |
| BX/T | Box (Telecom) | KO | Kerb Outlet |
| BX/W | Box (Water) | LP | Lampost |
| BM | Benchmark | LT | Light |
| BO | Bollard | MH | Manhole |
| BS | Bus Stop | Mkr | Marker |
| Bin | Bin | POST | Post (General) |
| BT | Telecom Cover | PB | Post Box |
| CCTV | Air Valve | RE | Rodding Eye |
| CL | Cover Level | RS | Road Sign |
| DK | Dropkerb | Stay | Cable Stay |
| DP | Downpipe | SV | Stop Valve |
| DP/G | Downpipe/Gully | TL | Traffic Light |
| EC | Electric Cover | TFR | Taken From Records |
| EOR | End of Records | TP | Telecom Pole |
| EOS | End of Survey | TV | Cable TV |
| EOT | End of Trace | UTGA | Unable to Gain Access |
| EP | Electric Pole | UTL | Unable to Lift |
| ER | Earth Rod | UTS | Unable to Survey |
| FH | Fire Hydrant | UTT | Unable to Trace |
| FL | Floor Level | WL | Water Level |
| FP | Flag Pole | WS | Window Sample |
| GP | Gate Post | | |
| G | Girder | | |
| GU | Gully | | |

Measured Survey Abbreviations

| | | | |
|---|---|---|---|
| AC | Air Conditioning | SCH | Structural Ceiling Height |
| AH | Access Hatch | SKY | Sky Light |
| AP | Access Panel | W | Window Height |
| BH | Beam Height | | |
| C | Cill Height | | |
| DH | Door Height | | |
| FCH | False Ceiling Height | | |
| FL | Floor Level | | |
| Ht. | Height (General) | | |
| RD | Radiator | | |

Layout Key




CO-ORDINATES AND ELEVATIONS ARE SET BY GNSS AT STATION DS1.
CO-ORDINATES ARE TO OS NATIONAL GRID USING OSTN15 TRANSFORMATION
LEVELS ARE TO ORDNANCE DATUM USING OSGM15 GEOID MODEL.
THE REMAINDER OF THE SURVEY IS TO SCALE FACTOR 1 PLANE GRID.


Accuracies are commensurate with the stated scale of the survey.

RICS Regulated by RICS

| rev | by | date | notes | check |
|---|---|---|---|---|
| A | HM | 11/09/23 | Additional survey detail added | EH |

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e: office@landform-surveys.co.uk www.landform-surveys.co.uk

CLIENT
TOWN.
Nile Street, Sunderland, SR1 1EY

TITLE
# Topographic Survey

| | | | | drawing no | scale |
|---|---|---|---|---|---|
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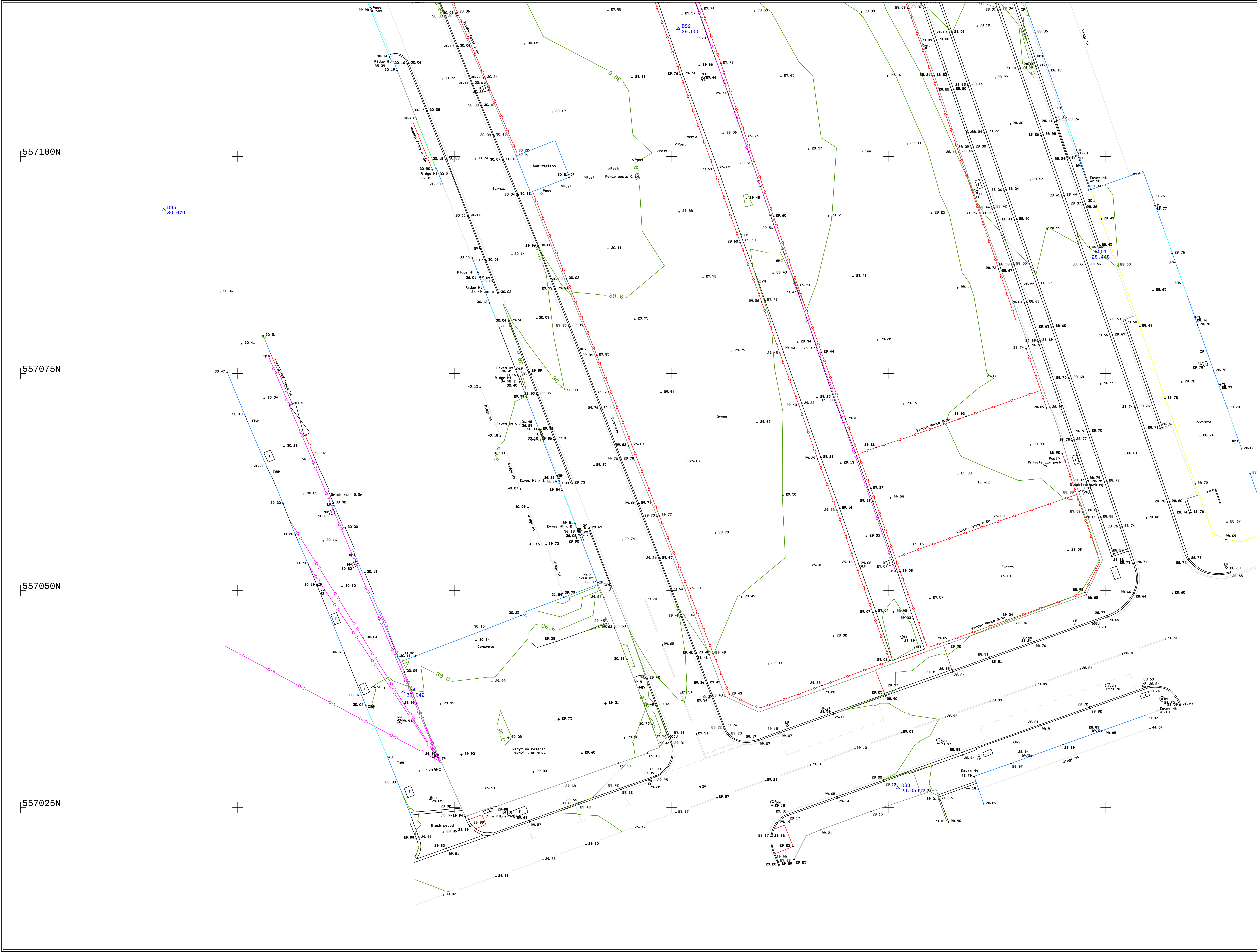
| checked | MR | date | 25/08/23 | | |
| clients Ref | | | | | |




## Legend

**Boundary Type and Description**

| | |
|---|---|
| C/B | Close Board |
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| O/B | Open Board |
| Pal | Palisade |
| M/R | Metal Railings |
| Pick | Picket |
| P/R | Post & Rail |
| P/W | Post & Wire |
| W/M | Wire Mesh |
| Brick | Brick Wall |
| Brick Ret. | Brick Retaining Wall |
| Stone | Stone Wall |
| Stone Ret. | Stone Retaining Wall |
| Block | Block Wall |
| Misc | Misc. Wall |
| | Gate |

**Vegetation**

Hedge
Edge of Hedge
Edge of Canopy
Tree and Trunk
Stump
Bush
Verge

**General Utility Linestyles**

| | |
|---|---|
| CD | Drainage Combined |
| FD | Drainage Foul |
| SD | Drainage Surface |
| UD | Drainage Unidentified |
| O/C | O/Head Combined |
| O/E | O/Head Electric |
| | O/Head Lines |
| O/T | O/Head Telecom |

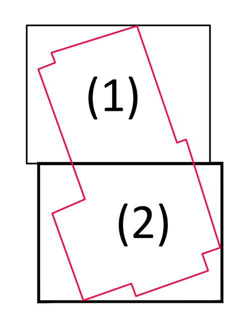
**General Survey Abbreviations**

| | | | |
|---|---|---|---|
| AV | Air Valve | GV | Gas Valve |
| BH | Borehole Collar | HP | Hand Pit |
| BX | Box (General) | IBO | Illuminated Bollard |
| BX/E | Box (Elec) | IC | Inspection Cover |
| BX/G | Box (Gas) | IL | Invert Level |
| BX/T | Box (Telecom) | KO | Kerb Outlet |
| BX/W | Box (Water) | LP | Lampost |
| BM | Benchmark | LT | Light |
| BO | Bollard | MH | Manhole |
| BS | Bus Stop | Mkr | Marker |
| Bin | Bin | POST | Post (General) |
| BT | Telecom Cover | PB | Post Box |
| CCTV | Air Valve | RE | Rodding Eye |
| CL | Cover Level | RS | Road Sign |
| DK | Dropkerb | Stay | Cable Stay |
| DP | Downpipe | SV | Stop Valve |
| DP/G | Downpipe/Gully | TL | Traffic Light |
| EC | Electric Cover | TFR | Taken From Records |
| EOR | End of Records | TP | Telecom Pole |
| EOS | End of Survey | TV | Cable TV |
| EOT | End of Trace | UTGA | Unable to Gain Access |
| EP | Electric Pole | UTL | Unable to Lift |
| ER | Earth Rod | UTS | Unable to Survey |
| FH | Fire Hydrant | UTT | Unable to Trace |
| FL | Floor Level | WL | Water Level |
| FP | Flag Pole | WS | Window Sample |
| GP | Gate Post | | |
| G | Girder | | |
| GU | Gully | | |

**Measured Survey Abbreviations**

| | | | |
|---|---|---|---|
| AC | Air Conditioning | SCH | Structural Ceiling Height |
| AH | Access Hatch | SKY | Sky Light |
| AP | Access Panel | W | Window Height |
| BH | Beam Height | | |
| C | Cill Height | | |
| DH | Door Height | | |
| FCH | False Ceiling Height | | |
| FL | Floor Level | | |
| Ht. | Height (General) | | |
| RD | Radiator | | |

**Layout Key**




CO-ORDINATES AND ELEVATIONS ARE SET BY GNSS AT STATION DS1.
CO-ORDINATES ARE TO OS NATIONAL GRID USING OSTN15 TRANSFORMATION
LEVELS ARE TO ORDNANCE DATUM USING OSGM15 GEOID MODEL.
THE REMAINDER OF THE SURVEY IS TO SCALE FACTOR 1 PLANE GRID.


Accuracies are commensurate with the stated scale of the survey.

Regulated by RICS

| rev | by | date | notes | check |
|---|---|---|---|---|
| A | HM | 11/09/23 | Additional survey detail added | EH |

Landform Surveys
professional surveying solutions
Suite 18, YBN, Delta Bank Road, Gateshead. NE11 9DJ
Tel: 0191 2765636
e: office@landform-surveys.co.uk www.landform-surveys.co.uk

CLIENT

TOWN.

Nile Street, Sunderland, SR1 1EY

TITLE

# Topographic Survey

| | | | | drawing no | scale |
|---|---|---|---|---|---|
| drawn | HM | date | 25/08/23 | J342-002 | 1/200@A1 |
| checked | MR | date | 25/08/23 | | |
| clients Ref | | | | | |

## Appendix C: BGS historical borehole logs

NZ 43 NW /116

# RECORD OF BOREHOLE 7 SUNDERLAND

GROUND LEVEL 29.7 m O.D.

BORING: STARTED 26.10.70
BORING: FINISHED 26.10.70
HOLE SIZE 0.15 m Dia.

| SAMPLE OR TEST DEPTH | TYPE | LEGEND | CHANGE OF STRATA DEPTH | O.D. LEVEL | DESCRIPTION |
|---|---|---|---|---|---|
| | | | 0.9 | 28.8 | Ashes, clay, brick fragments (made ground). |
| 0.9 - 1.2 | S(27) | | | | |
| 1.5 | D1 | | | | |
| 3.0 | D2 | | | | |
| 4.6 | D3 | | 4.9 | 24.8 | Medium dense light brown medium to fine sand with a trace of silt and clay. |
| 5.3 - 5.8 | U(4)1 | | | | |
| 6.0 | D4 | | 7.0 | 22.7 | Stiff dark brown boulder clay. |
| 7.0 - 7.5 | U(4)2 | | | | |
| 7.6 | D5 | | | | Stiff to very stiff dark grey brown boulder clay. |
| 9.1 | D6 | | | | |

REMARKS

Borehole dry.

KEY: D — DISTURBED SAMPLE
B — BULK DISTURBED SAMPLE
W — WATER SAMPLE
U — UNDISTURBED SAMPLE
S { } STANDARD PENETRATION TEST
C { } CONE PENETRATION TEST
NO. OF BLOWS FOR 300 mm PENETRATION IN BRACKETS

PRE-PILING SURVEYS LTD PETERBOROUGH

NZ 45 NW/116

RECORD OF BOREHOLE 7 (cont). SUNDERLAND.

GROUND LEVEL 29.7 m O.D.

BORING: STARTED 26.10.70
BORING: FINISHED 26.10.70
HOLE SIZE 0.15 m Dia.

| SAMPLE OR TEST | | CHANGE OF STRATA | | | |
|---|---|---|---|---|---|
| DEPTH | TYPE | LEGEND | DEPTH | O.D. LEVEL | DESCRIPTION |
| | | | | | Stiff to very stiff dark grey brown boulder clay. |
| 10.7 | 07 | | 10.7 | 19.0 | |
| | | | | | Presumed bedrock. |

REMARKS Borehole dry.

KEY: D — DISTURBED SAMPLE
B — BULK DISTURBED SAMPLE
W — WATER SAMPLE
U — UNDISTURBED SAMPLE
S ( ) STANDARD PENETRATION TEST
C ( ) CONE PENETRATION TEST
NO. OF BLOWS FOR 300 mm
PENETRATION IN BRACKETS

PRE-PILING SURVEYS LTD., PETERBOROUGH

RECORD OF BOREHOLE 7A SUNDERLAND. NZ 55 NE/225

GROUND LEVEL 30.9 m O.D.

BORING: STARTED 5.11.70.
BORING: FINISHED 5.11.70.
HOLE SIZE 0.15 m Dia.

| SAMPLE OR TEST DEPTH | TYPE | LEGEND | CHANGE OF STRATA DEPTH | O.D. LEVEL | DESCRIPTION |
|---|---|---|---|---|---|
| | | | | | Clay ashes brick fragments (made ground). |
| | | | 1.4 | 29.5 | |
| 1.5<br>1.5 - 1.8 | D1 | | | | Medium dense light brown silty fine sand. |
| 3.0 | D2 | | | | |
| 4.6 | D3 | | | | |
| | | | 5.5 | 25.4 | |
| | | | | | Presumed bedrock. |

REMARKS Borehole dry.

KEY: D — DISTURBED SAMPLE
B — BULK DISTURBED SAMPLE
W— WATER SAMPLE
U— UNDISTURBED SAMPLE
S ( ) STANDARD PENETRATION TEST
C ( ) CONE PENETRATION TEST
NO. OF BLOWS FOR 300 mm PENETRATION IN BRACKETS

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## Appendix D: LLFA Correspondence

## Oliver Dodd

**From:** Juliet Brown <Juliet.Brown@sunderland.gov.uk>
**Sent:** 31 August 2023 16:48
**To:** Oliver Dodd
**Subject:** RE: Planning Reference 23/00314/P1

**Categories:** Filed by Newforma

Hi Oliver,

No worries.

Yes, as the site is within an SPZ and has Medium-High GW Connectivity we would not allow any infiltration and the system would need to be wrapped. There are very few areas of Sunderland where we would allow infiltration, given the geology.

Thank you,

**Juliet Brown**
Flood and Coastal Engineer | Flooding & Coastal

Sunderland City Council
City Hall
Plater Way
Sunderland
SR1 3AA

Email: Juliet.brown@sunderland.gov.uk



---

**From:** Oliver Dodd <oliver.dodd@civicengineers.com>
**Sent:** Thursday, August 31, 2023 3:11 PM
**To:** Juliet Brown <Juliet.Brown@sunderland.gov.uk>
**Subject:** RE: Planning Reference 23/00314/P1

Hi Juliet,

Thank you very much for sharing.

We will base our design for planning on no infiltration.

One final (I hope) question: is the medium-high groundwater connectivity a complete blocker for allowing infiltration?

I only ask because we are carrying out site investigations (results not expected until after planning submission) and if the ground conditions are favourable, it would be good to incorporate infiltration or at least remove the requirement for membranes beneath all SuDS features. I don't think being in SPZ3 alone would prevent infiltration, if rates are good and groundwater levels low enough. We could also limit infiltration to the medium groundwater connectivity areas of site.

Kind regards,
Oliver

Oliver Dodd (he/him)
Principal Engineer

DDI: 020 7253 2977
Mobile: 07401564648

Manchester / London / Leeds / Glasgow

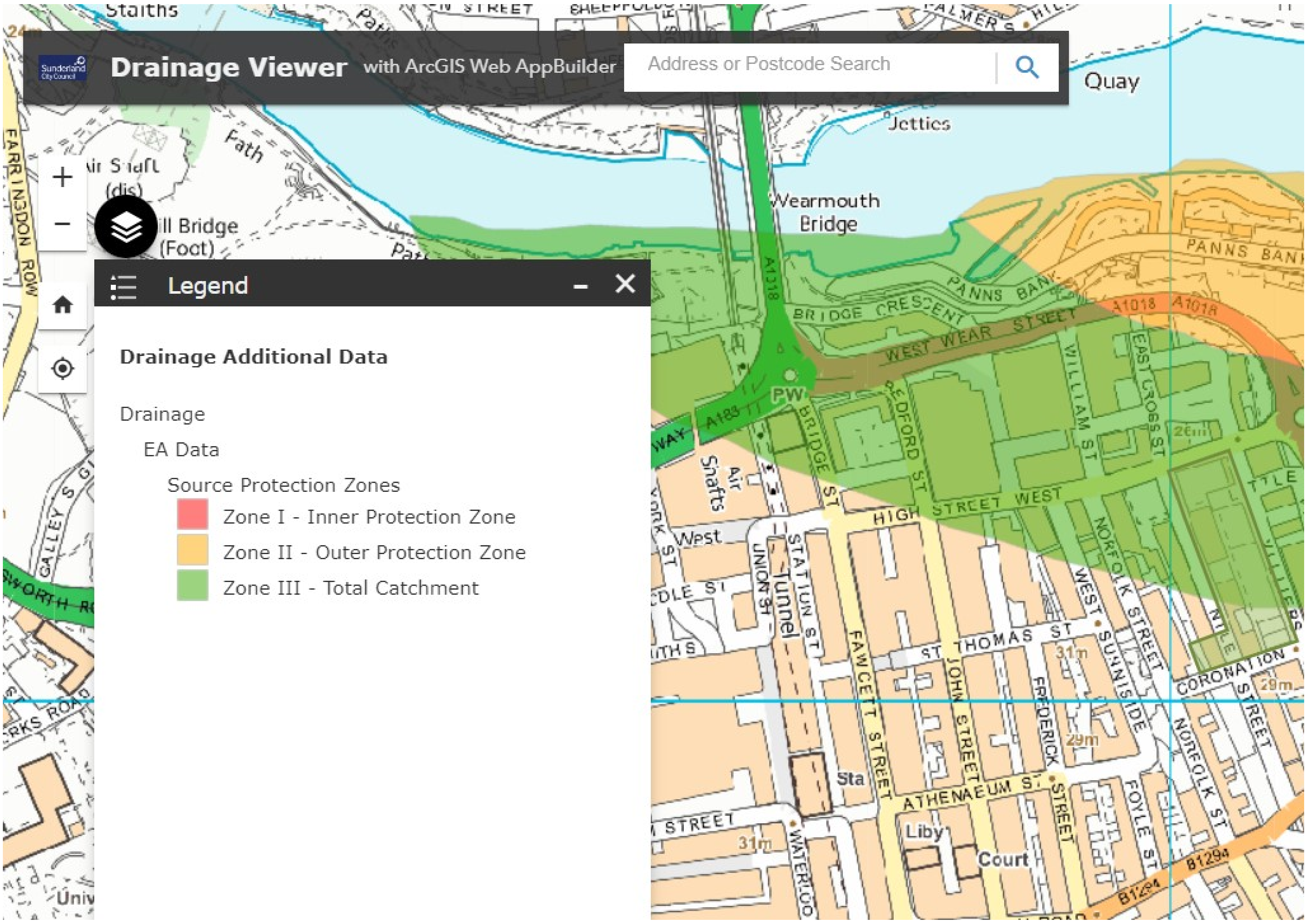


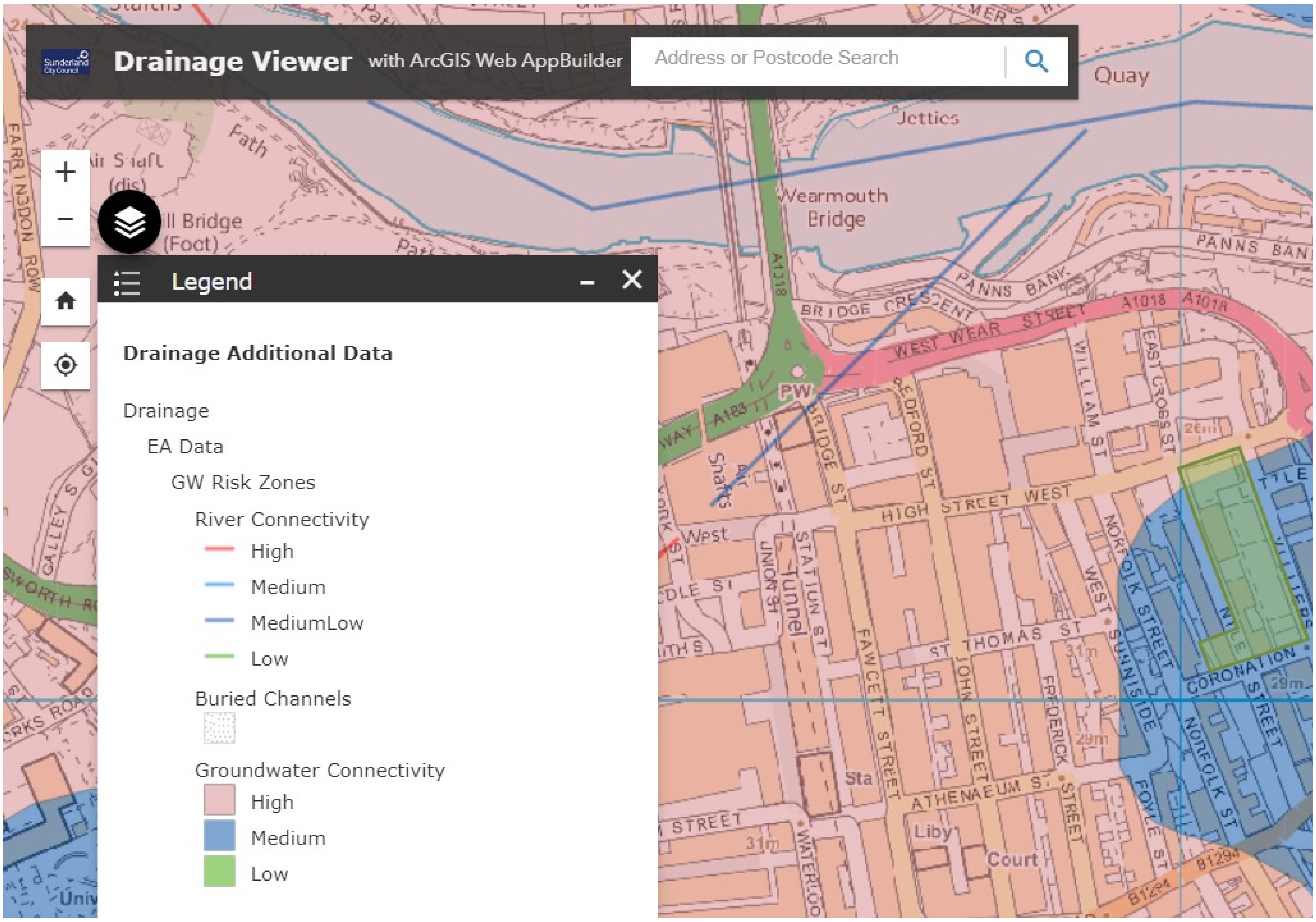
---

**From:** Juliet Brown <Juliet.Brown@sunderland.gov.uk>
**Sent:** Wednesday, August 30, 2023 10:39 AM
**To:** Oliver Dodd <oliver.dodd@civicengineers.com>
**Subject:** RE: Planning Reference 23/00314/P1

Hi Oliver,

See below screenshots of our information, at present I am unable to share the full dataset with you.


Drainage Viewer
with ArcGIS Web AppBuilder
Address or Postcode Search
Legend
Drainage Additional Data
Drainage
EA Data
Source Protection Zones
Zone I - Inner Protection Zone
Zone II - Outer Protection Zone
Zone III - Total Catchment
Quay
Jetties
Wearmouth Bridge
PANNS BANK
BRIDGE CRESCENT
WEST WEAR STREET
HIGH STREET WEST
ST THOMAS ST
ATHENAEUM ST
FAWCETT STREET
JOHN STREET
FREDERICK
NORFOLK STREET
CORONATION STREET
WILLIAM ST
Tunnel
Sta
Liby
Court


Drainage Viewer
with ArcGIS Web AppBuilder
Address or Postcode Search
Legend
Drainage Additional Data
Drainage
EA Data
GW Risk Zones
River Connectivity
High
Medium
MediumLow
Low
Buried Channels
Groundwater Connectivity
High
Medium
Low
Quay
Jetties
Wearmouth Bridge
PANNS BANK
BRIDGE CRESCENT
WEST WEAR STREET
HIGH STREET WEST
ST THOMAS ST
ATHENAEUM ST
FAWCETT STREET
JOHN STREET
FREDERICK
NORFOLK STREET
CORONATION STREET
WILLIAM ST
Tunnel
Sta
Liby
Court

The runoff arrangement sounds good to me, hopefully you'll be able to have just two outfalls and discharge at the QBar rate.

Thank you,

**Juliet Brown**
Flood and Coastal Engineer | Flooding & Coastal

Sunderland City Council
City Hall
Plater Way
Sunderland
SR1 3AA

Email: Juliet.brown@sunderland.gov.uk



**From:** Oliver Dodd <oliver.dodd@civicengineers.com>
**Sent:** Tuesday, August 29, 2023 4:36 PM
**To:** Juliet Brown <Juliet.Brown@sunderland.gov.uk>; LLFA <LLFA@sunderland.gov.uk>
**Cc:** Dominique Pitman <dominique@civicengineers.com>
**Subject:** RE: Planning Reference 23/00314/P1

Hi Juliet,

Thank you very much for the clarification and information provided.

For points 5 and 6 are you able to provide, or lead me to, the information provided by the EA (to which you refer)?

The Defra magic map shows the site in an area of medium Groundwater Vulnerability and not within any Source Protection Zone. The site is also not within a Drinking Water Safeguard Zone (Groundwater).

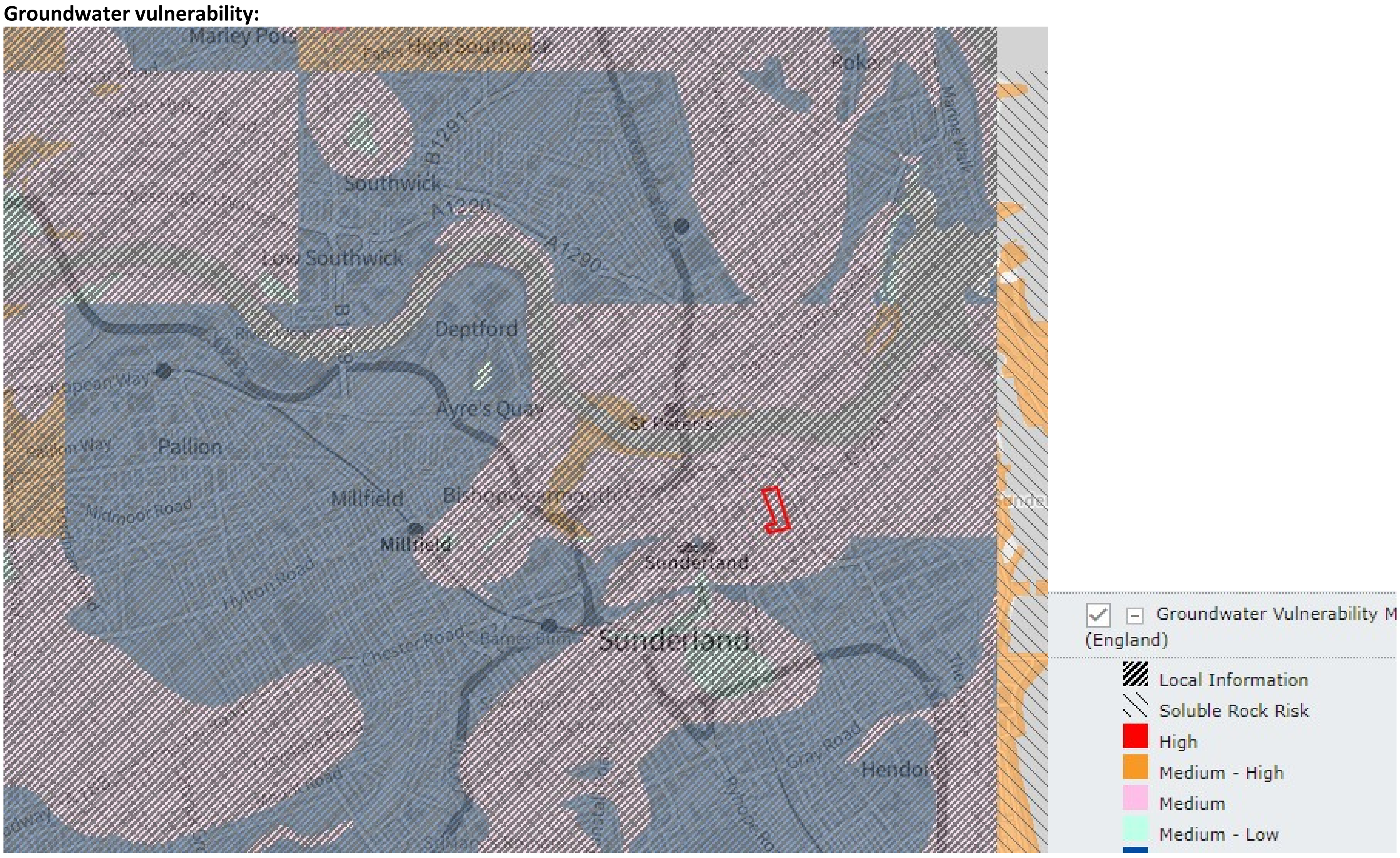
The Groundwater Vulnerability map indicates the site is within an area with 'Local Information' and 'Soluble Rock Risk'. Are these the reason for the higher classification of medium-high risk you stated?

Also, regarding point 7; we have calculated the greenfield runoff rate, which is 3.24 l/s, see attached. Based on the site layout and levels, and assuming infiltration is not possible, we are anticipating three or more (hopefully not) surface water outfalls. I note the requirement for a 50mm minimum orifice size on flow controls places a constraint on the achievable minimum outflow from site. The flow from a 50mm hydrobrake vortex flow control device is approx. 1.5 l/s, meaning with two outfalls we could achieve 3.24 l/s, however, with three or more outfalls we will be exceeding this target. Please can you confirm my understanding is correct and acceptable?

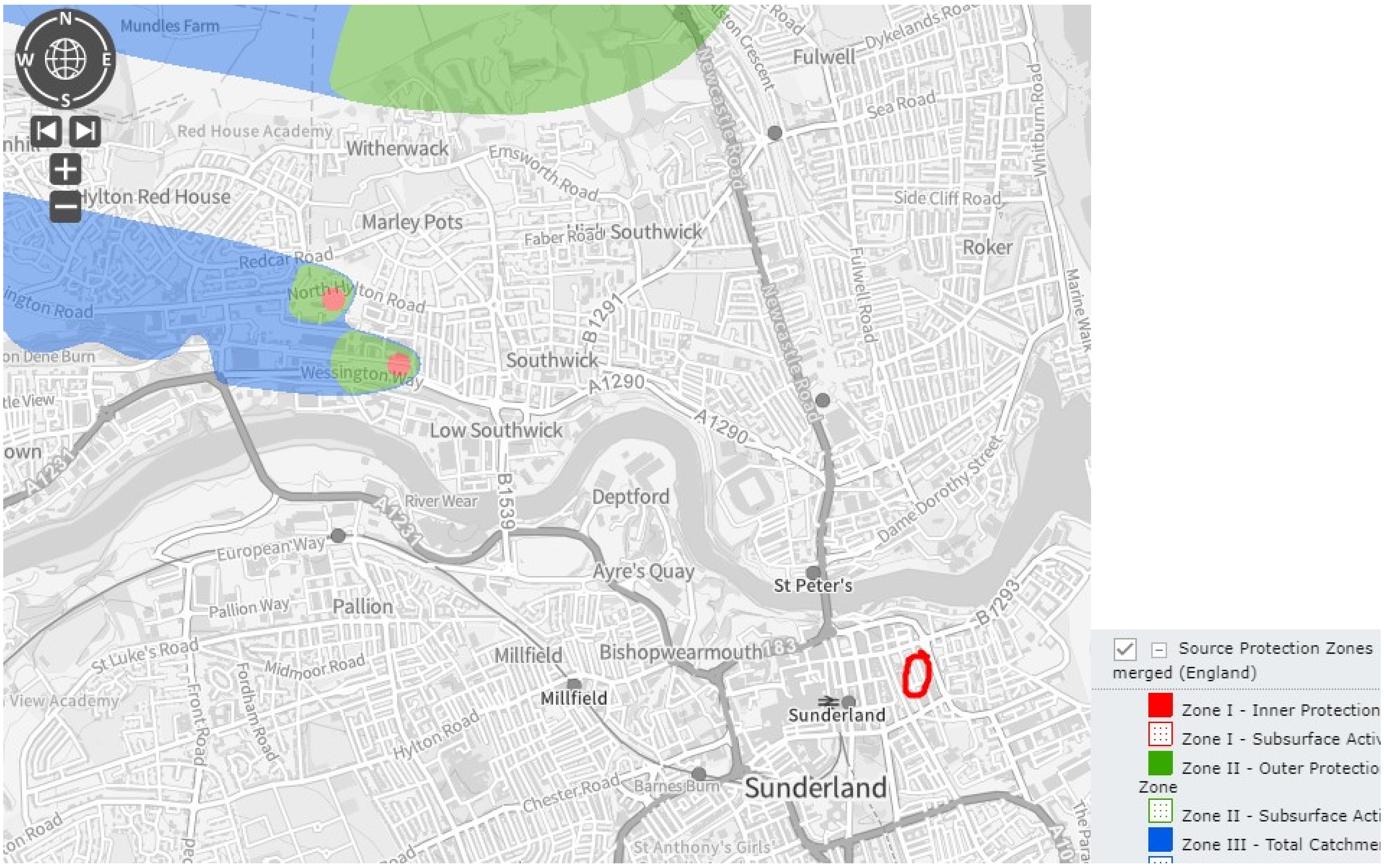
Many thanks for your feedback so far. Happy to have a quick call if that's easier, and you have the time.

See extracts below:

**Groundwater vulnerability:**




**SPZs:**




Kind regards,
Oliver


Oliver Dodd (he/him)
Principal Engineer

DDI: 020 7253 2977
Mobile: 07401564648

Manchester / London / Leeds / Glasgow




**From:** Juliet Brown <Juliet.Brown@sunderland.gov.uk>
**Sent:** Tuesday, August 29, 2023 2:17 PM
**To:** Oliver Dodd <oliver.dodd@civicengineers.com>; LLFA <LLFA@sunderland.gov.uk>
**Cc:** Felix Spiers <felix.spiers@civicengineers.com>; Dominique Pitman <dominique@civicengineers.com>
**Subject:** RE: Planning Reference 23/00314/P1



Hi Oliver,

Please see my responses in red below and all relevant information attached.

Let me know if you need anything else.

Thank you,


**Juliet Brown**
Flood and Coastal Engineer | Flooding & Coastal

Sunderland City Council
City Hall
Plater Way
Sunderland
SR1 3AA

Email: Juliet.brown@sunderland.gov.uk

Please consider the environment before printing this email

**From:** Oliver Dodd <oliver.dodd@civicengineers.com>
**Sent:** Monday, August 21, 2023 6:09 PM
**To:** Juliet Brown <Juliet.Brown@sunderland.gov.uk>; LLFA <LLFA@sunderland.gov.uk>
**Cc:** Felix Spiers <felix.spiers@civicengineers.com>; Dominique Pitman <dominique@civicengineers.com>
**Subject:** FW: Planning Reference 23/00314/P1

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Dear Juliet,

Just to introduce myself, I am working for Civic Engineers (who are appointed to TOWN) looking at the flood risk and drainage design for the Nile and Villiers project.

We have some questions relating to your comments on the pre-app which we are hoping you can help clarify. I have listed these in blue against your comments in the email below.

As agreed with your colleague Phil Smith, we will be using the following design criteria for the surface water drainage design:

- Discharge restricted to QBar.
- Minimum (protected) orifice size of 50mm for flow controls (this may impact the minimum achievable discharge rate).
- 45% allowance for climate change.
- CV values of 0.84 for winter and 0.75 for summer.

I note the requirement for a 10% allowance for urban creep also.

Thanks in advance.

Kind regards,
Oliver

Oliver Dodd (he/him)
Principal Engineer

DDI: 020 7253 2977
Mobile: 07401564648

Manchester / London / Leeds / Glasgow



**From:** Juliet Brown <Juliet.Brown@sunderland.gov.uk>
**Sent:** 23 March 2023 15:52
**To:** DC <DC@sunderland.gov.uk>
**Cc:** LLFA <LLFA@sunderland.gov.uk>
**Subject:** Planning Reference 23/00314/P1

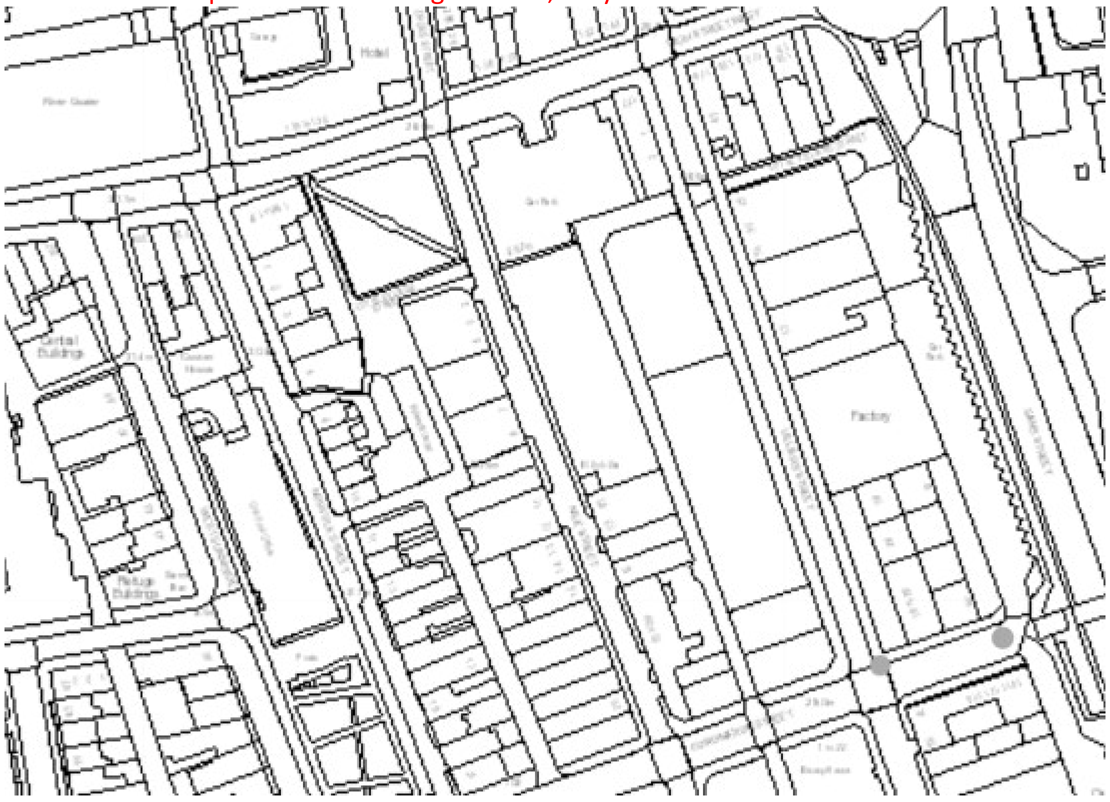
Hello,

With regard to Planning Reference 23/00314/P1 and in relation to flood risk and drainage I have the following comments.

In accordance with Sunderland City Council (SCC) validation checklist (see part 15) a Flood Risk Assessment and Drainage Strategy should be submitted with any major application, and minerals and waste applications. The 7 North East Lead Local Flood Authorities (LLFA) have new developer guidance on SuDS and a proforma on Sustainable Drainage (see Local Standards attached). The developer should use this guidance to develop site design and aid submission of appropriate details with the LLFA in line with the approved Local Flood Risk Management Strategy.

1. There is no drainage information supplied, so I'm only able to comment broadly.
2. The proposed development is located within Flood Zone 1 and the site is not at risk of surface water flooding.
3. There is a <25% risk of groundwater flooding.
   Please can you share the 2017 version of the SFRA including appendices? I can't find it online (only a draft without the appendices). Based on the topography and nearby borehole records we are not anticipating there to be any significant risk of groundwater flooding. See Attached. This classification comes from information provided by the EA.
4. There are no records of flooding incidents within 100m of the site.
   Is this for all types of flooding? We will quote this fact directly unless it is based on information available within the SFRA or LFRMS reports? My colleague emailed last week with a query related to 'outstanding drainage problems' shown on drawing number 2009s0243-SCC-C1 which is an appendix of the 2010 SFRA available on the SCC website. Figure 4-2 of the 2011 Prelim FRA (available on the national archives) shows two SCC highway maintenance flooding incidents within the vicinity of the site, although, the scale of the drawing does not allow for a measurable distance to be obtained. We are assuming both figures refer to the same

problem/incident? Is there any further information available on that? I've just double checked and there have been no flood incidents recorded within the site or within 100m of the site. There are two historical records shown by the grey dots below, which correspond with both Figure 4-2 and 2009s0243-SCC-C1. However, these have been placed in the wrong location, they should be located on Coronation Crescent in Hetton instead. These two points can therefore be ignored.



5. The hierarchy of discharge should be followed. Infiltration is not possible due to medium-high groundwater connectivity and therefore discharge to the River Wear is the preferred method, which is located approximately 235m north of the site.
   Please confirm where the medium-high groundwater connectivity classification comes from? This classification comes from information provided by the EA.
   To connect to the river we would need to requisition a sewer hundreds of metres long across public and private third party land, which is not feasible. Discharge to watercourse must be considered if the watercourse is less than 250m from the site. Sufficient reasoning must be given to prove this is not feasible (Policy WWE3).
6. The site is partially located within a source protection zone and fully located within the medium and high groundwater connectivity zones, so the drainage system must be wrapped.
   The Defra magic maps show that the site is not located within a Source Protection Zone. Please can you confirm where this information is from? This information is provided by the EA and shows the site is partially located within the 'Zone III – Total Catchment' SPZ.
7. Greenfield run off rates should be applied, with appropriate storage up to and including the 1 in 100 year + 45% climate change allowance on the 360-minute storm event.
8. Green SUDS should be incorporated within the design.
9. Source control interception should be applied to the impermeable area, retaining the first 5mm of rainfall on site.

Sunderland City Council require sustainable drainage and source control for all major applications. For full application submissions the applicant should provide details of this sustainable drainage including plans, sections, water quality treatment and hydraulic modelling files (MDX etc.), in line with CIRIA c753 guidance. The drainage response template attached will be used to provide ongoing discussions in regards to documents submitted for approval. Early consideration should be given to the provision of source control-interception to ensure the first 5mm rainfall is retained on site (see Section 24.8 Interception in CIRIA C753). The applicant should also show how the site drainage will manage an extreme storm event. Sustainable drainage source control should include water quality treatment in line with the C753 simple indices method unless another method is more appropriate. The provision of green roofs is a priority on flat roofed buildings to provide interception and treatment and where water re-use through rainwater harvesting is possible it is promoted.
Provision should also be made for creating SUDS to benefit local ecology and amenity, be it linking green spaces, providing ponding water, selecting flowering plants, incorporating paths and seating areas and even in some cases considering places for habitat for some species. It may be possible to use SUDS to contribute to Biodiversity Net Gain using Defra metrics in consultation with the SCC ecology team.

The applicant should review Policies WWE2-WWE4 (Flood risk and coastal management, Water management and water quality) in the Core Strategy Development Plan, the SCC Strategic Flood Risk Assessment (2017) and the Local Flood Risk Management Strategy (2016).

Please let me know if you have any further questions or queries.

**Juliet Brown**
Flood and Coastal Engineer | Flooding & Coastal

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SR1 3AA

Email: Juliet.brown@sunderland.gov.uk

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## Appendix E: Soil Site Report from Cranfield University

# Soil Site Report

## Extended Soil Report

## Nile and Villiers

Easting: 440046
Northing: 557089
Site Area: 1km x 1km

Prepared for: Oliver Dodd, Civic Engineers
Date: 23 Aug 2023

# Citation

Citations to this report should be made as follows:

Cranfield University (2023) Soil site report, Extended Soil Report for location 440046E, 557089N, 1km x 1km, Cranfield University.

Produced using Soil Site Reporter

# Disclaimer

# About this report

This Soil Site Report identifies and describes the properties and capacities of the soil at your specified location as recorded in the National Soil Map for England and Wales. It has been produced by Cranfield University's National Soil Resources Institute.

The National Soil Map represents the most accurate and comprehensive source of information about the soil at the national coverage in England and Wales. It maps the distribution of soil mapping units (termed soil associations) which are defined in terms of the main soil types (or soil series) that were recorded for each soil association during field soil survey. Each soil association is named after its principal soil series and these bear the location name from where they were first described (e.g. Windsor). Each of these soil associations have differing environmental characteristics (physical, chemical and biological) and it is by mapping these properties that the range of thematic maps in this report have been produced.

Soil types and properties vary locally, as well as at the landscape scale. It is not possible to identify precisely the soil conditions at a specific location without first making a site visit. We have therefore provided you with information about the range of soil types we have identified at and around your selected location. Schematic diagrams are also provided to aid accurate identification of the soil series at your site.

Whilst an eight-figure national grid reference should be accurate to within 100m, a single rural Postcode can cover a relatively large geographical area. Postcodes can therefore be a less precise basis for specifying a location. The maps indicate the bounded area the reports relate to.

Your Site Soil Report will enable you to:

- identify the soils most likely to be present at and immediately around your specified location;
- understand the patterns of soil variation around your location and how these correlate with changes in landscape;
- identify the nature and properties of each soil type present within the area;
- understand the relevant capacities and limitations of each of the soils and how these might impact on a range of factors such as surface water quality.

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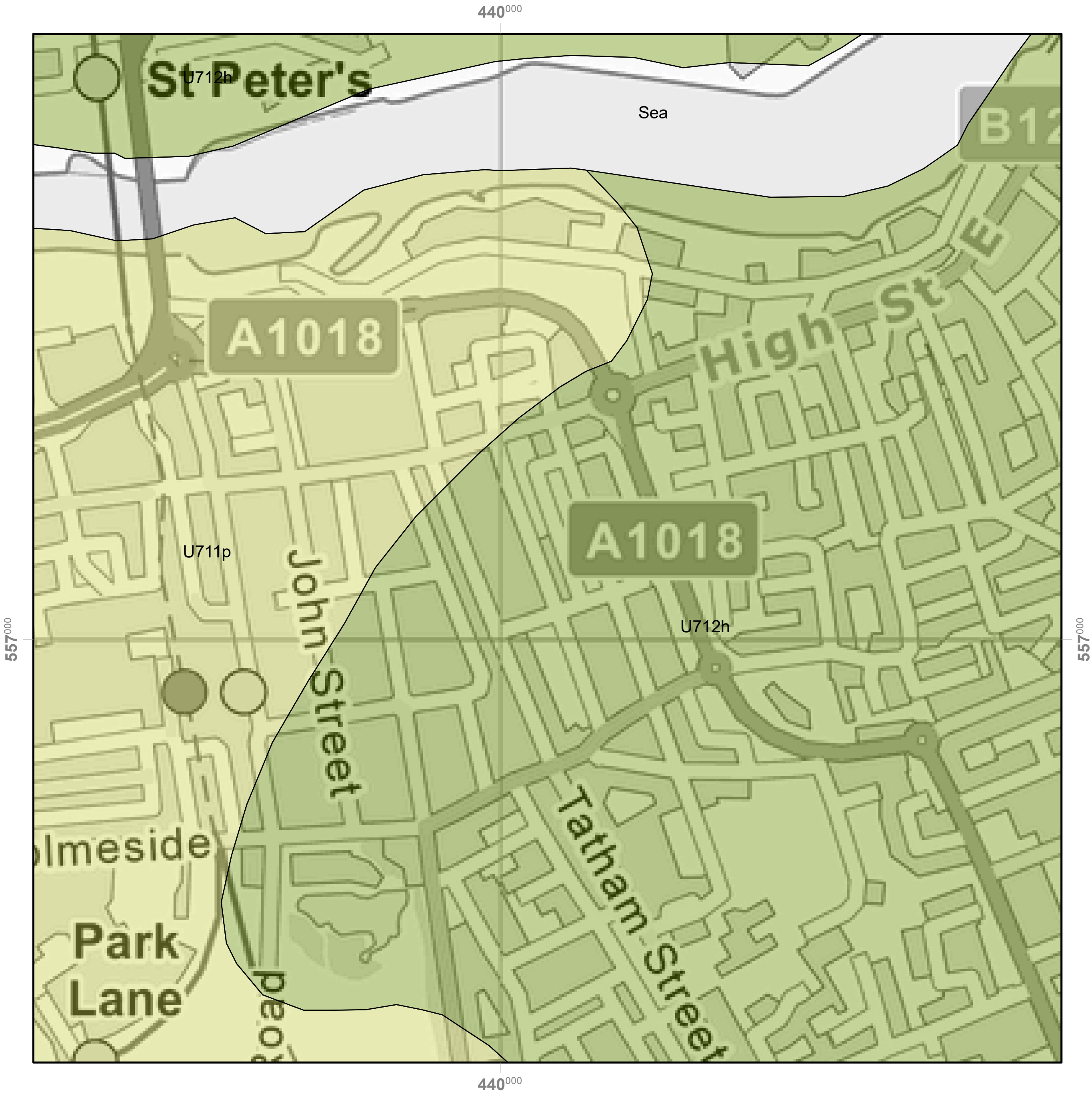
# 1. Soil Thematic Maps

This section contains a series of maps of the area surrounding your selected location, presenting a number of themes relating to the characteristics of the soils. These provide an overview of the nature and condition of the local soil conditions. It is these conditions that may be used to infer the response of an area to certain events (with the soil as a receptor), such as pollution contamination from a chemical spill, or an inappropriate pesticide application and the likelihood of these materials passing though the soil to groundwater. Other assessments provide an insight into the way a location may impact, by corrosive attack or ground movement, upon structures or assets within the ground, for example building or engineering foundations or pipes and street furniture.

Soil is a dynamic environment with many intersecting processes, chemical, physical and biological at play. Even soils 'sealed' over by concrete and bitumen are not completely dormant. The way soils respond to events and actions can vary considerably according to the properties of the soil as well as other related factors such as land-use, vegetation, topography and climate. There are many threats facing our national soil resource today and importance should be given to identifying the best measures aimed towards soil protection, ensuring the usage of soils in the most sustainable way. This report is therefore a useful snapshot of the soil properties for your given area, providing a summary of a broad range of ground conditions


Figure 1: Location of study area

# 1a Soils - Spatial Distribution






## Soils - Spatial Distribution Key

711p DUNKESWICK
*Slowly permeable seasonally waterlogged fine loamy and fine loamy over clayey soils*

712h FOGGATHORPE 1
*Slowly permeable seasonally waterlogged clayey and fine loamy over clayey soils, often stoneless.*

SOIL ASSOCIATION DESCRIPTION

Soil associations represent a group of soil series (soil types) which are typically found occurring together, associated in the landscape (Avery, 1973; 1980; Clayden and Hollis, 1984). Soil associations may occur in many geographical locations around the country where the environmental conditions are comparable. For each of these soil associations, a collection of soil types (or soil series) are recorded together with their approximate proportions within the association. Soil associations have codes as well as textual names, thus code '554a' refers to the 'Frilford' association. Where a code is prefixed with 'U', the area is predominantly urbanised (e.g. 'U571v'). The soil associations for your location, as mapped above, are described in more detail in Section 2: Soil Association Descriptions.

# 1b Hydrology of Soil Type (HOST)



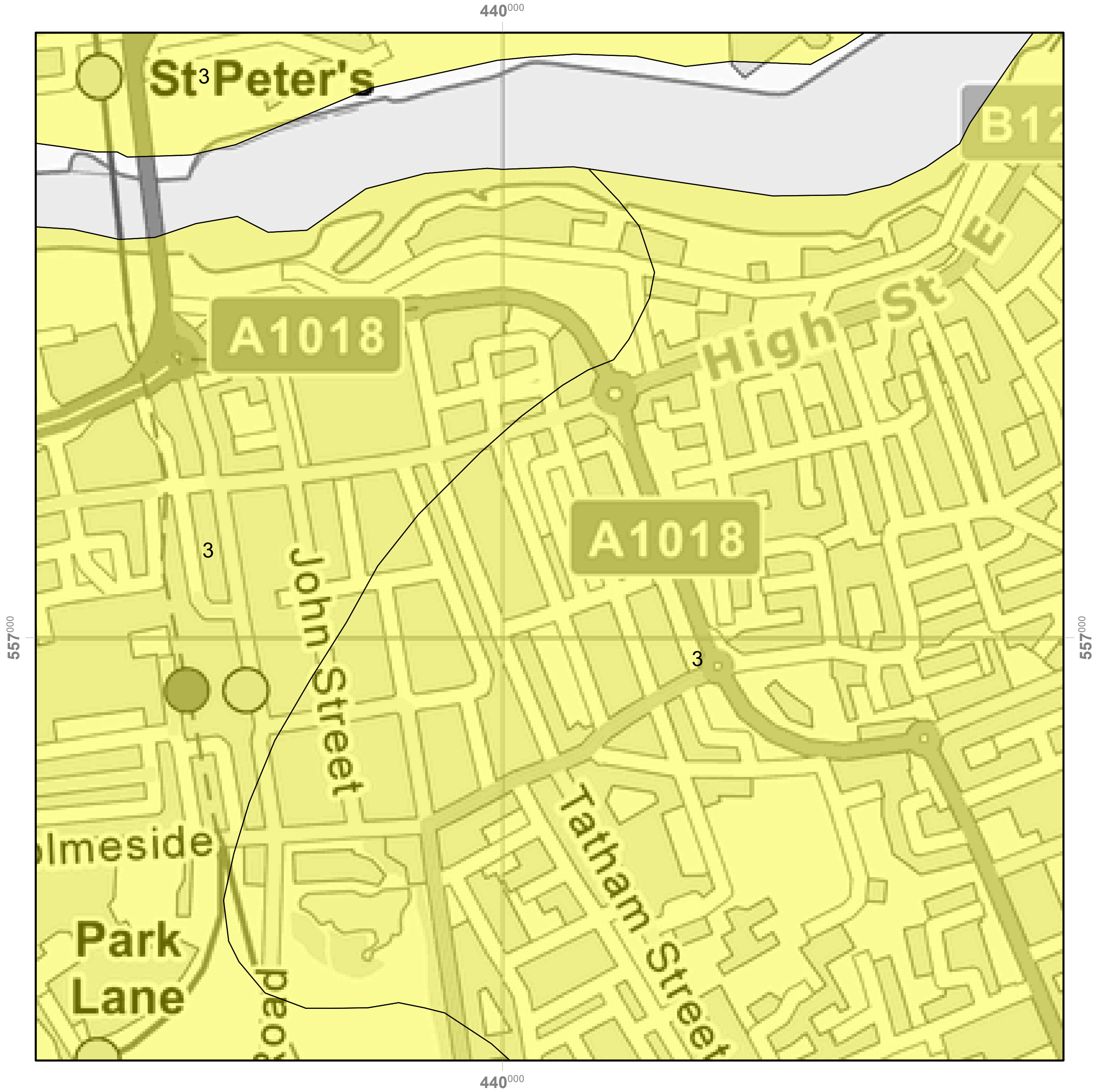

## Hydrology of Soil Type (HOST) Key

24 Slowly permeable, seasonally waterlogged soils over slowly permeable substrates with negligible storage capacity

HOST CLASS DESCRIPTION

The Hydrology of Soil Types (HOST) classification describes the dominant pathways of water movement through the soil and, where appropriate, the underlying substrate. Eleven drainage models are defined according to the permeability of the soil and its substrate and the depth to a groundwater table, where one is present (Boorman et al,1995). These are further subdivided into 29 HOST classes to which all soil series have been assigned. These classes identify the way soil water flows are partitioned, with water passing over, laterally through, or vertically down the soil column. Analysis of the river hydrograph and the extent of soil series for several hundred gauged catchments allowed mean values for catchment hydrological variables to be identified for each HOST class, The HOST classification is widely used to predict river flows and the frequency and severity of flood events and also to model the behaviour of diffuse pollutants (Hollis et al, 1995).

# 1c Ground Movement Potential






## Ground Movement Potential Key

3 Moderate

* If a High class is starred, a Very High ground movement potential is likely to be achieved if these soils are drained to an effective depth of at least two metres.

GROUND MOVEMENT POTENTIAL DESCRIPTION

Clay-related ground movement is the most widespread cause of foundation failure in the UK and is linked to seasonal swelling and shrinkage of the clay. The content of clay within the soils of your selected area has therefore a direct bearing upon the likelihood of ground movement.

Among the inorganic particles that constitute the solid component of any soil, clay particles are the smallest and defined as being less than 0.002 mm - equivalent spherical diameter (esd) in size. Clay particles occur in most kinds of soil but they only begin to exert a predominant influence on the behaviour of the whole soil where there is more than 35 per cent (by weight) of clay-sized material present.

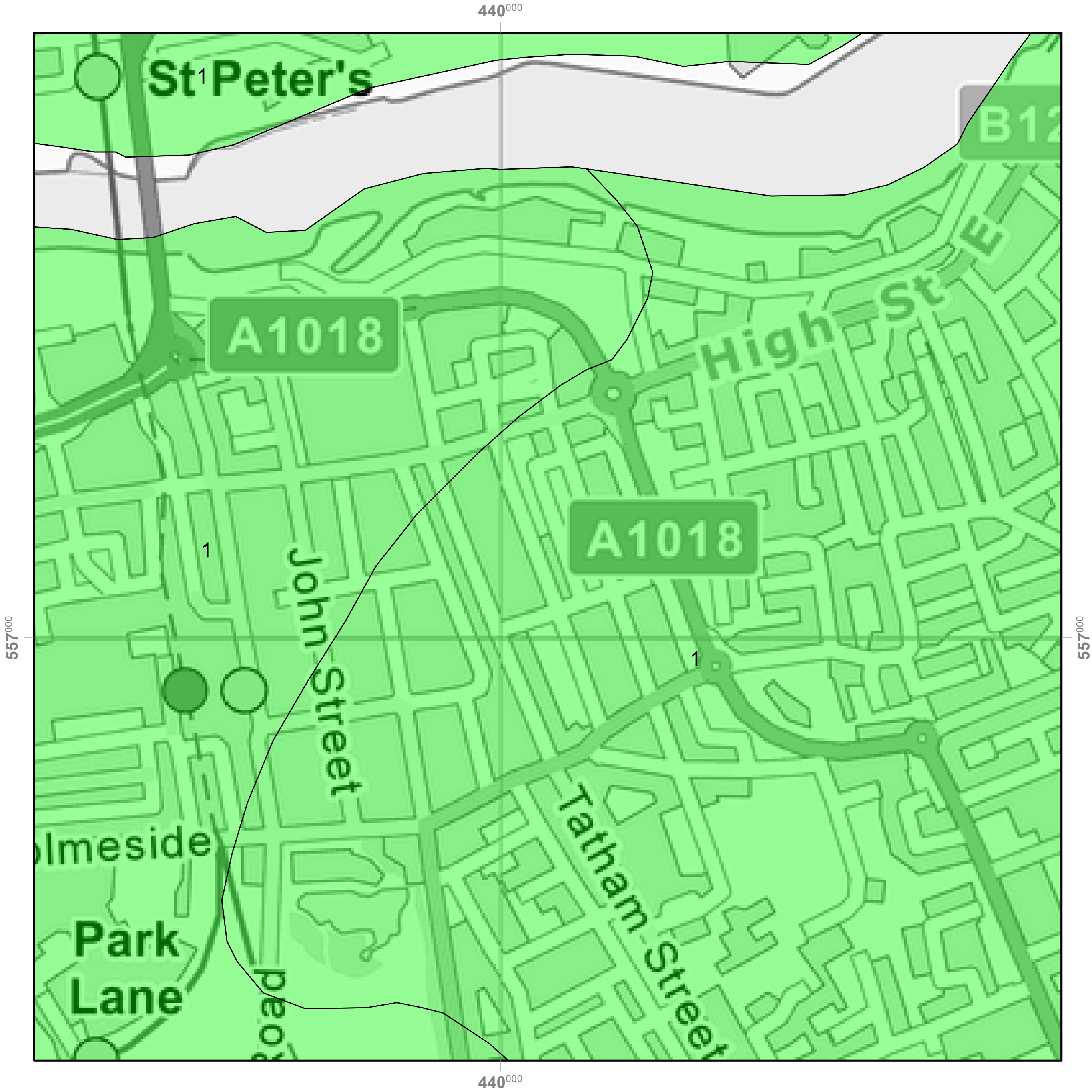
Because clay particles are very small and commonly platy in shape they have an immense surface area onto which water can be attracted, relative to the total volume of the soil material. In addition to surface attraction or inter-crystalline absorption of water, some clay minerals, those with three layers of atoms (most other kinds of clay have only two layers of atoms) are able to absorb and hold additional water between these layers. It is these types of clay mineral, which are widespread in British soils and commonly known as smectites that have the greatest capacity to shrink and swell.

In a natural undisturbed condition, the moisture content of deep subsoil clay does not change greatly through the year and consequently there are no changes in volume leading to shrinkage and swelling. However, when clays are exposed at or near the ground surface and especially when vegetation is rooting in them seasonal moisture and volume changes can be dramatic. Plants and trees transpire moisture from the soil to support their growth and transfer necessary nutrients into their structures. Surface evaporation also takes place from soil and plant structures, and the combination of evaporation from surfaces and transpiration by plants and trees is termed evapotranspiration. Thus, the layer of soil material down to 2m depth into which plants will root is critical when assessing the vulnerability of land to subsidence.

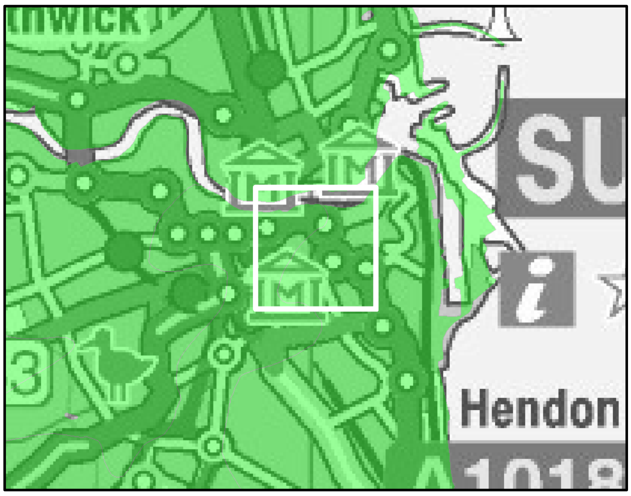
Whenever soil moisture is continuously being replenished by rainfall, the soil moisture reserves will be unaffected by the removal of moisture by plants as there is no net loss. However, in many parts of Britain, particularly in the south and east, summer rainfall is small and is exceeded by evapotranspiration. Water reserves are then not sufficiently replenished by rainfall and so a soil moisture deficit develops. The water removed from a clayey soil by evapotranspiration leads to a reduction in soil volume and the consequent shrinkage causes stress in the soil materials leading in turn to stress on building foundations that are resting in the soil (Hallett, et al, 1994).

The foundations themselves may then move and thus cause damage to building structures. This problem can be exacerbated by the fact that the soil beneath the structure may not dry out uniformly, so that any lateral pressure exerted on the building foundation is made effectively greater. This assessment identifies the likelihood of soil conditions being prone to ground movement given these other factors.

# 1d Flood Vulnerability





## Flood Vulnerability Key

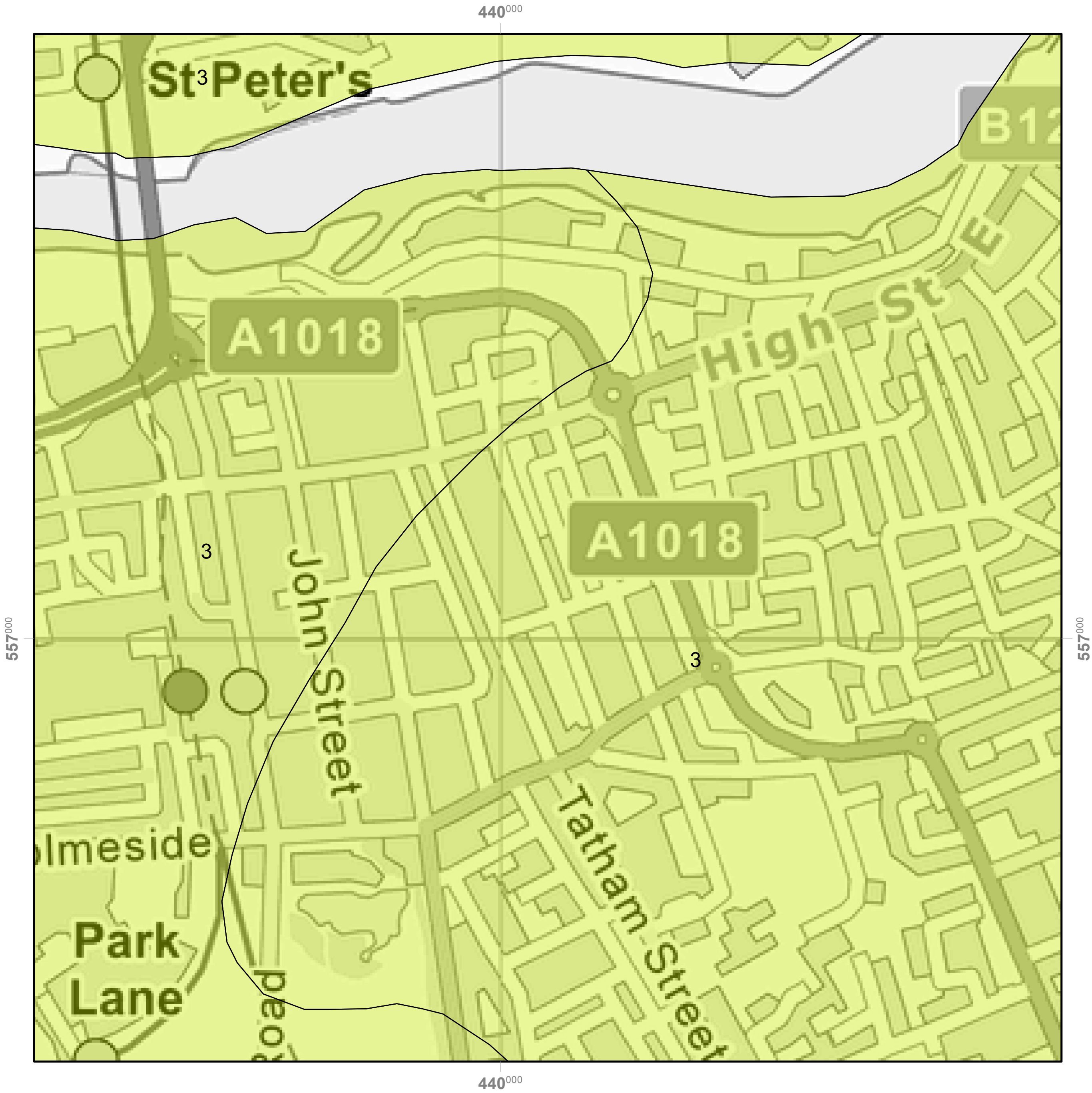
| | |
|---|---|
| (green) | 1 Minor risk |

FLOOD VULNERABILITY DESCRIPTION

The inundation of properties by flood water can occur in a number of circumstances. Surface run-off can collect on low-lying land from upslope following heavy rainfall. More commonly rivers, lakes and/or the sea extend beyond their normal limits as a result of prolonged or intense rainfall, unusually high tides and/or extreme wind events. Water damage to properties and their contents is compounded by the deposition of sediment suspended in the flood waters. The spatial distribution of such waterborne sediment (or alluvium as defined in soil science) is one basis upon which land that has been subject to historical flooding can be mapped, and this forms a basis for present-day flooding risk assessment.

Both riverine and marine alluvium are identified as distinct soil parent materials within the British soil classifications. Combining soil map units that are dominated by soil series developed in alluvium across Great Britain identifies most of the land that is vulnerable to flooding. This assessment does not account for man-made flood defence measures, showing instead the areas where once water has stood.

# 1e Risk of Corrosion to Ferrous Iron






## Risk of Corrosion to Ferrous Iron Key

3 Moderately Aggressive

* If a class is starred, it is assumed that there are moderate amounts of sulphate in the soil. If there is abundant sulphate present, the soil may be one class more aggressive. Conversely, if there is very little sulphate, the soil may be one class less aggressive to

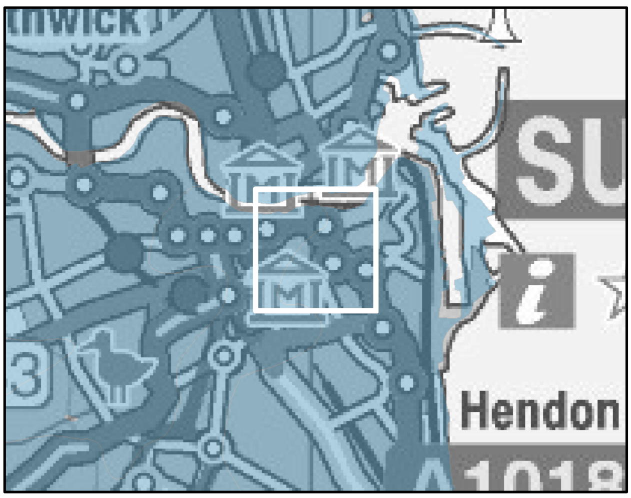
buried ferrous iron.

RISK OF CORROSION TO FERROUS IRON DESCRIPTION

Buried iron pipes and other infrastructure corrode at rates that are influenced by soil conditions (Jarvis and Hedges, 1994). Soil acidity, sulphide content, aeration and wetness all influence the corrosivity of the soil. These factors are used to map 5 major classes of relative corrosivity.

# 1f Pesticide Leaching Risk



## Pesticide Leaching Risk Key

L q Impermeable soils over soft substrates of low or negligible storage capacity that sometimes conceal groundwater bearing rocks at depth

PESTICIDE LEACHING CLASS DESCRIPTION

The natural permeability and water regime of soils are influential in determining the fate and behaviour of pesticides applied to the crop and soil surface (Hollis et al, 1995). A system of vulnerability assessment was devised as part of the national system for Policy and Practice for the Protection of Groundwater. This divided soils into three primary vulnerability classes.

H - Soils of high leaching capacity with little ability to attenuate non-adsorbed pesticide leaching which leave underlying groundwater vulnerable to pesticide contamination.

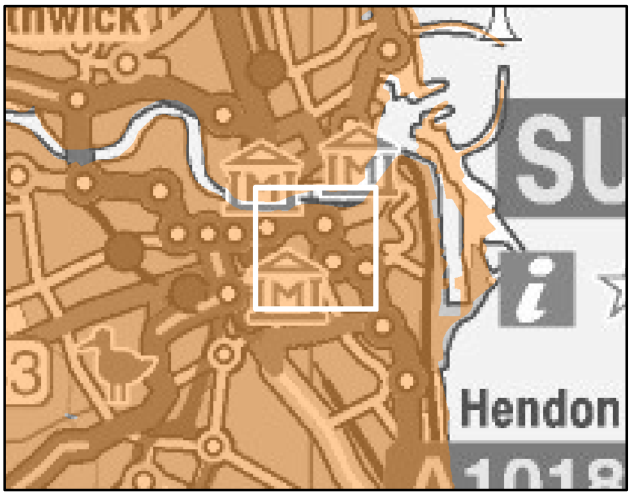
I - Soils of intermediate leaching capacity with a moderate ability to attenuate pesticide leaching.

L - Soils of low leaching capacity through which pesticides are unlikely to leach.

The primary classes have been further subdivided into nearly forty subclasses. These subclasses, with their descriptions, are mapped above. These classes do not account for differences in land cultivation, which can also have a significant impact on pesticide behaviour.

# 1g Pesticide Runoff Risk



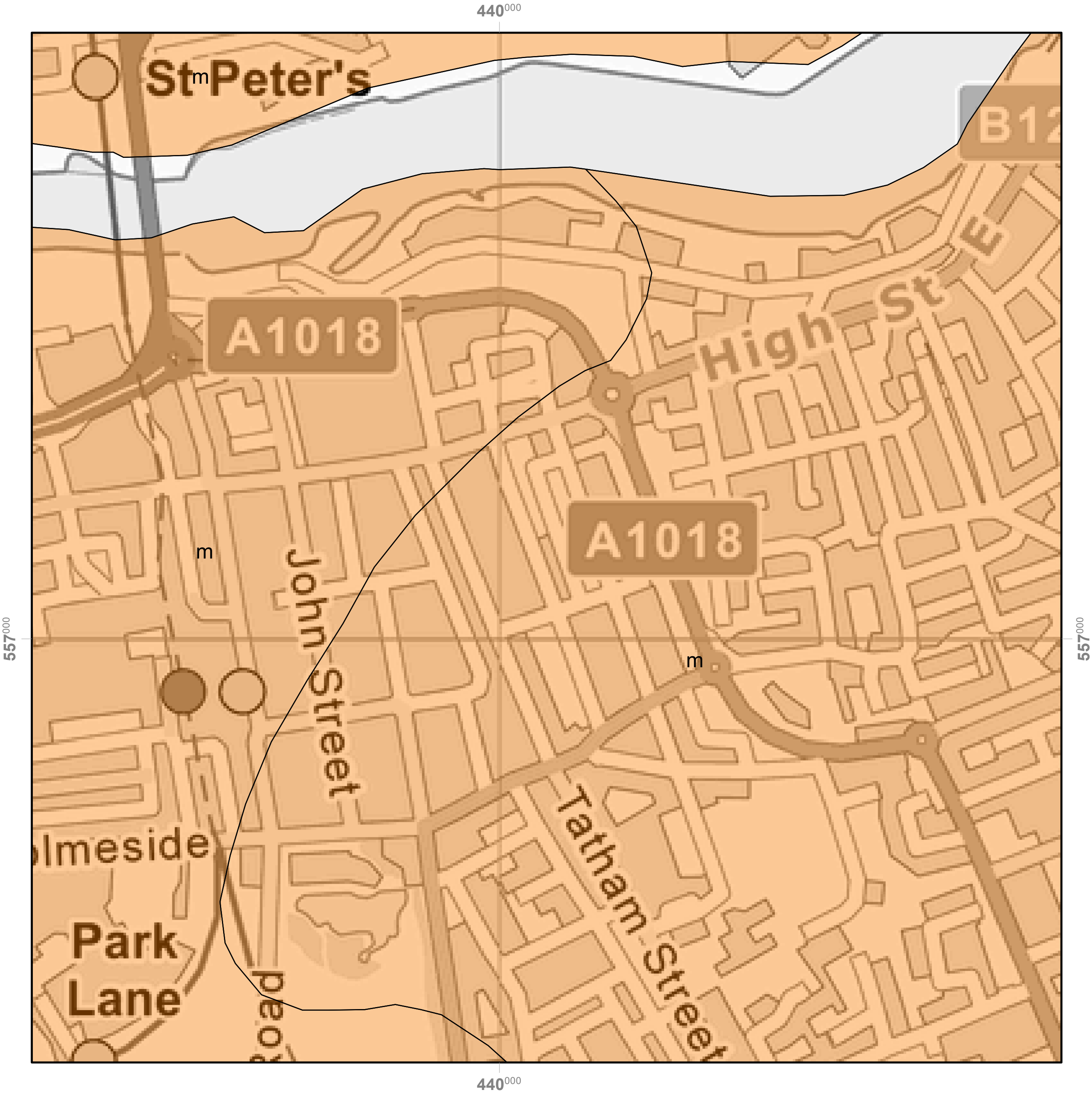
## Pesticide Runoff Risk Key

S2 High run-off potential.

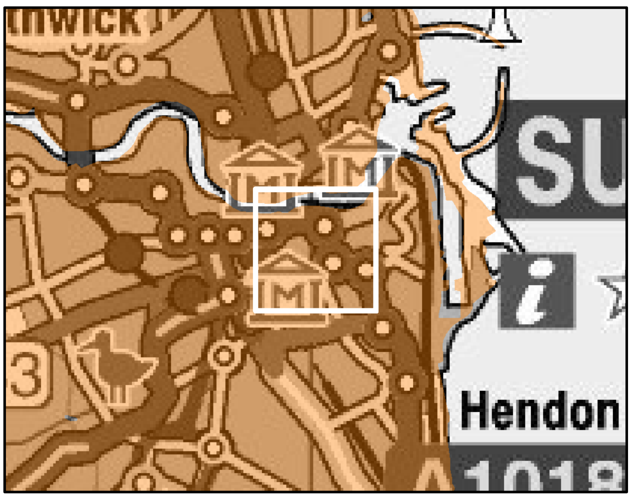
PESTICIDE RUNOFF RISK DESCRIPTION

The physical properties and natural water regime of soils influence the speed and extent of lateral water movement over and through the soil at different depths (Hollis et al, 1995). At as result, soils can be classed according to the potential for pesticide run-off. Five runoff potential classes are identified for mineral soils and a further two for peat soils.

# 1h Potential for Pesticide Adsorption





## Potential for Pesticide Adsorption Key

m Moderate adsorption potential.

POTENTIAL FOR PESTICIDE ADSORPTION DESCRIPTION

The physical properties and natural water regime of soils influence the speed and extent of lateral water movement over and through the soil at different depths (Hollis et al, 1995). The mineral soil classes are further subdivided according to their potential for pesticide adsorption.

Extended Soil Report

# 1i Hydrogeological Rock Type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## Hydrogeological Rock Type Key

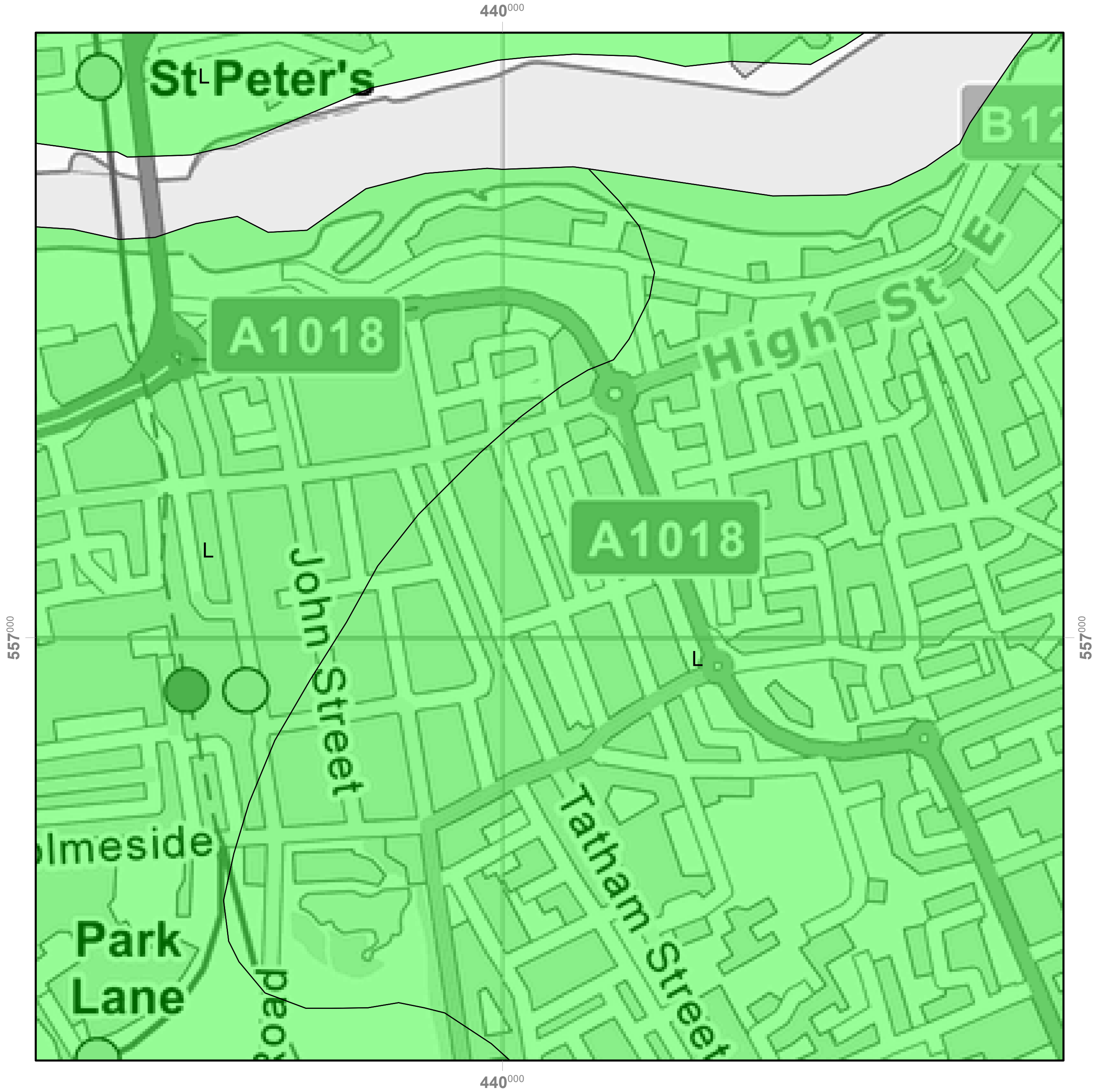
21 glaciolacustrine clays and silts

22 till and compact Head

HYDROGEOLOGICAL ROCK TYPE DESCRIPTION

The hydrogeological classification of the soil parent materials provides a framework for distinguishing between soil substrates according to their general permeability and whether they are likely to overlie an aquifer. Every soil series has been assigned one of the 32 substrate classes and each of these is characterised according to its permeability (being characterised as permeable, slowly permeable or impermeable). For further information, see Boorman et al (1995).

# 1j Ground Water Protection Policy (GWPP)

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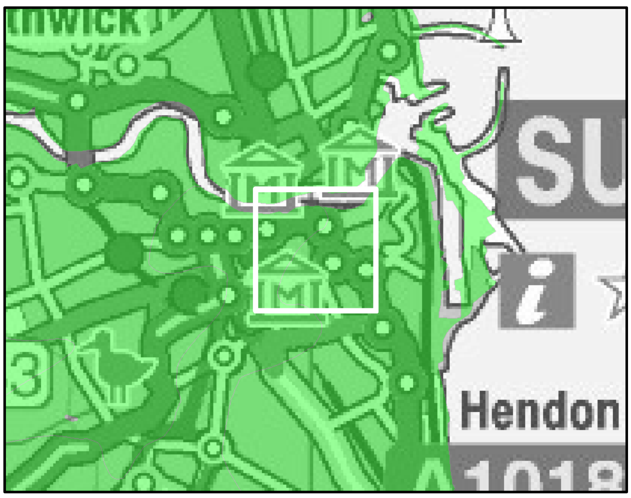


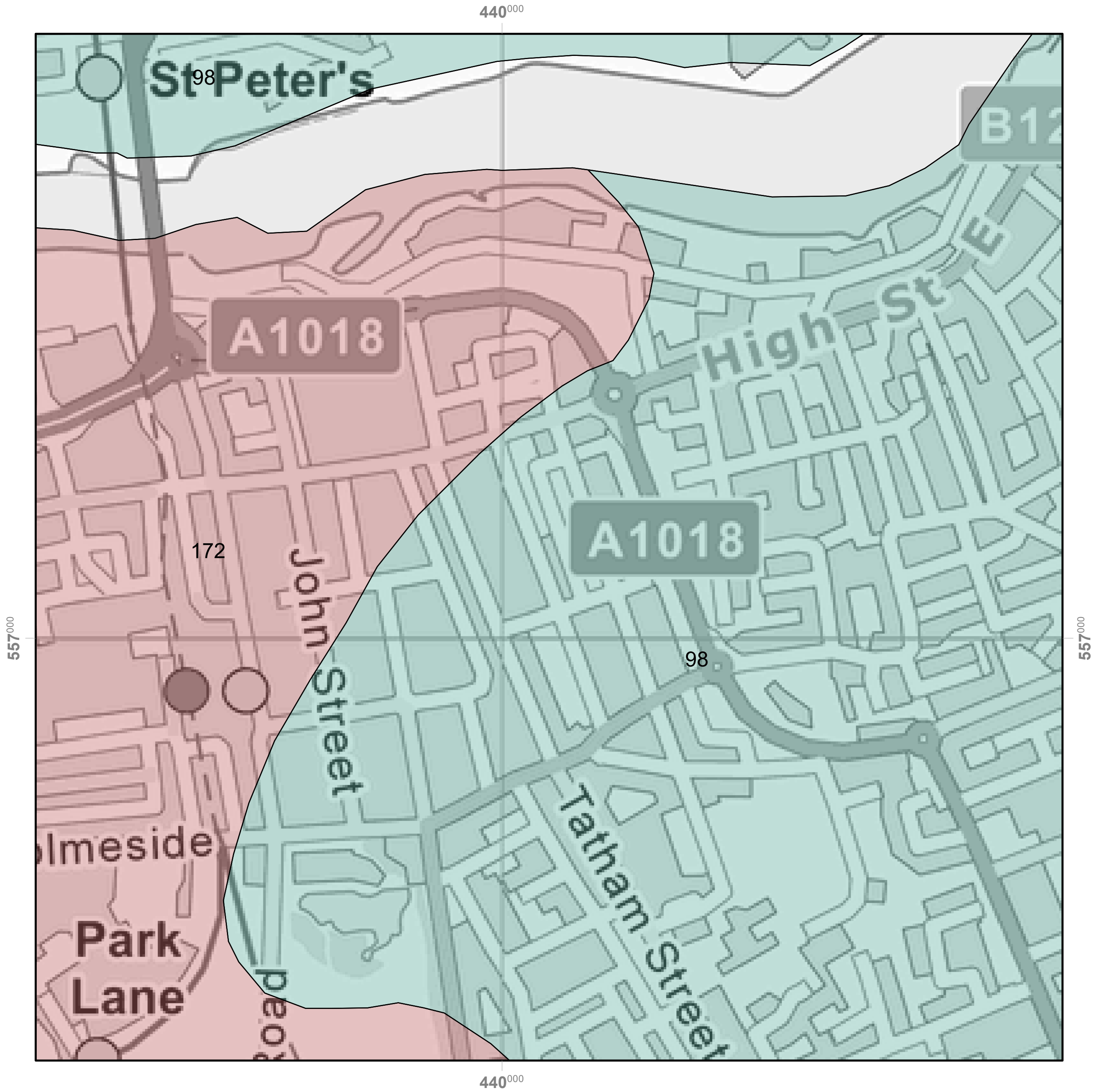
## Ground Water Protection Policy (GWPP) Key

L Soils in which pollutants are unlikely to penetrate the soil layer either because water movement is largely horizontal or because they have a large ability to attenuate diffuse source pollutants

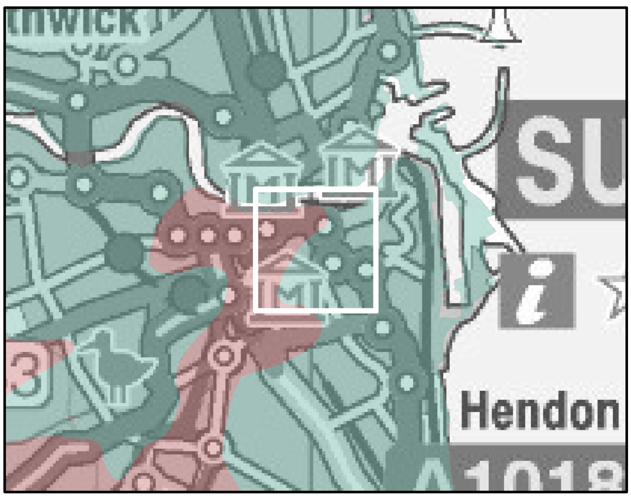
GWPP LEACHING CLASS DESCRIPTION

The Ground Water Protection Policy classes describe the leaching potential of pollutants through the soil (Hollis, 1991; Palmer et al, 1995). The likelihood of pollutants reaching ground water is described. Different classes of pollutants are described, including liquid discharges adsorbed and non-adsorbed pollutants.

# 1k Soil Parent Material





## Soil Parent Material Key

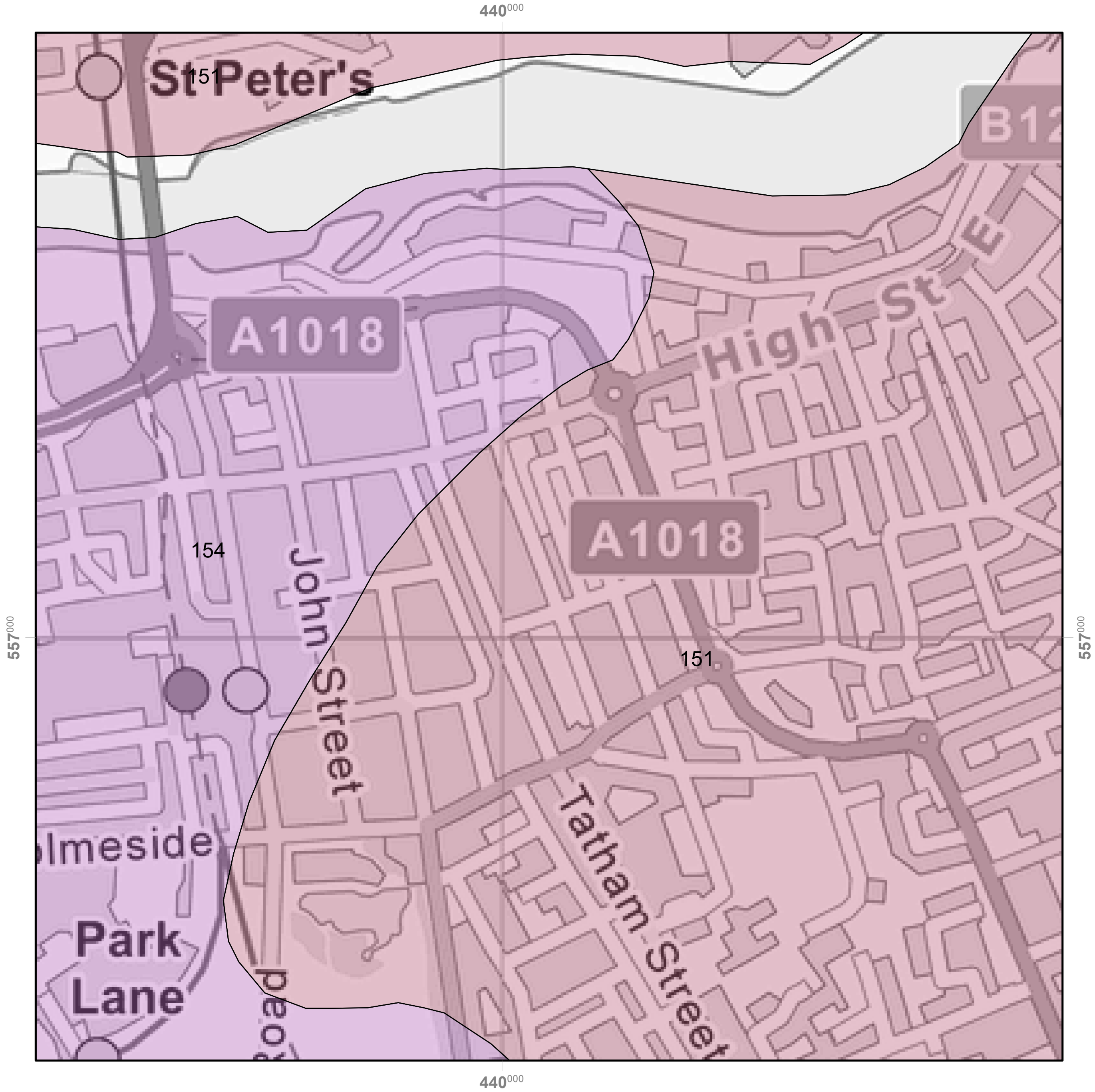
98 Glaciolacustrine drift and till

172 Till from Palaeozoic and Mesozoic sandstone and shale

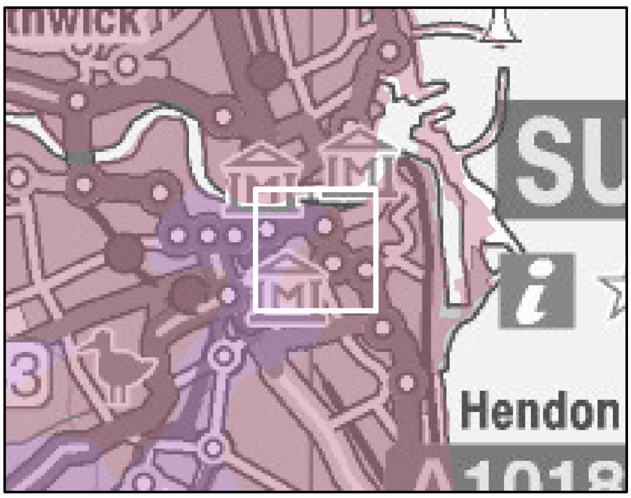
SOIL PARENT MATERIAL DESCRIPTION

Along with the effects of climate, relief, organisms and time, the underlying geology or 'parent material' has a very strong influence on the development of the soils of England and Wales. Through weathering, rocks contribute inorganic mineral grains to the soils and thus exhibit control on the soil texture. During the course of the creation of the national soil map, soil surveyors noted the parent material underlying each soil in England and Wales. It is these general descriptions of the regional geology which is provided in this map.

# 1I Expected Crops and Land Use





## Expected Crops and Land Use Key

151 Grassland and cereals in Northumberland; dairying on permanent grassland in Wales.

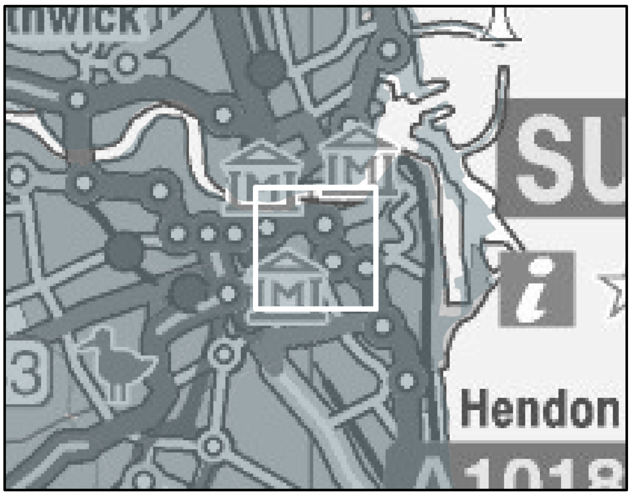
154 Grassland in moist lowlands, some arable cropping in drier lowlands.

EXPECTED CROPS AND LAND USE DESCRIPTION

Individual soils are commonly associated with particular forms of land cover and land use. Whilst the soil surveyors were mapping the whole of England and Wales, they took careful note of the range of use to which the land was being put. This map shows the most common forms of land use found on each soil unit.

# 1m Natural Soil Fertility



## Natural Soil Fertility Key

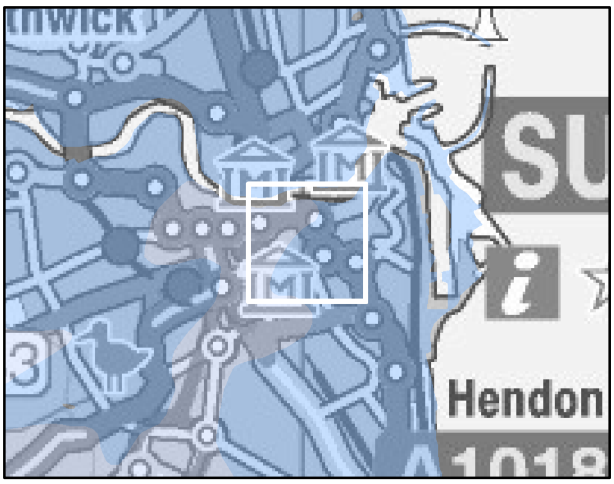
10 Moderate

NATURAL SOIL FERTILITY DESCRIPTION

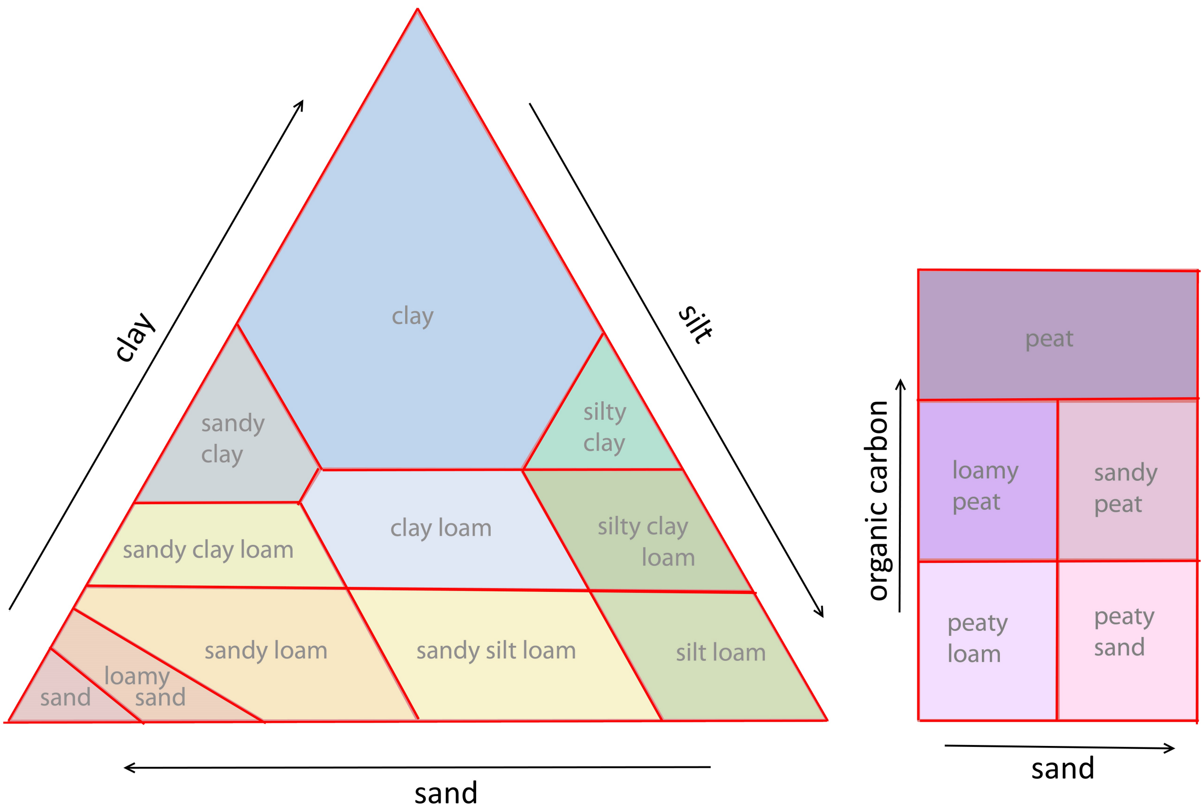
Soil fertility can be greatly altered by land management especially through the application of manures, lime and mineral fertilisers. What is shown in this map, however, is the likely natural fertility of each soil type. Soils that are very acid have low numbers of soil-living organisms and support heathland and acid woodland habitats. These are shown as of very low natural fertility. Soils identified as of low natural fertility are usually acid in reaction and are associated with a wide range of habitat types. The moderate class contains neutral to slightly acid soils, again with a wide range of potential habitats. Soil of high natural fertility are both naturally productive and able to support the base-rich pastures and woodlands that are now rarely encountered. Lime-rich soils contain chalk and limestone in excess, and are associated with downland, herb-rich pastures and chalk and limestone woodlands.

# 1n Topsoil Texture



## Topsoil Texture Key

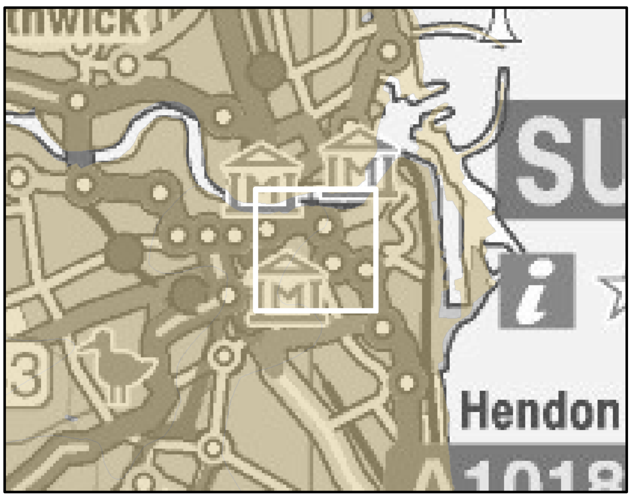



SOIL TEXTURE

Soil texture is a term used in soil science to describe the physical composition of the soil in terms of the size of mineral particles in the soil. Specifically, we are concerned with the relative proportions of sand, silt and clay. Soil texture can vary between each soil layer or horizon as one moves down the profile. This map indicates the soil texture group of the upper 30 cm of the soil. Loamy soils have a mix of sand, silt and clay-sized particles and are intermediate in character. Soils with a surface layer that is dominantly organic are described as Peaty. A good understanding of soil texture can enable better land management. (Hodgson et al, 2022)

## 1o Typical Habitats



## Typical Habitats Key

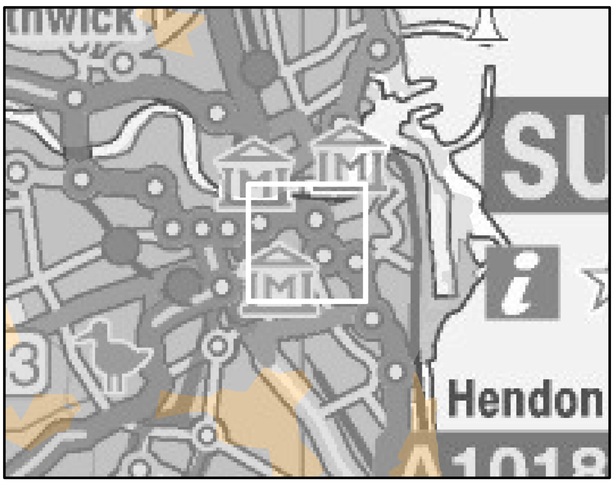
17 Seasonally wet pastures and woodlands

TYPICAL HABITATS DESCRIPTION

There is a close relationship between vegetation and the underlying soil. Information about the types of broad habitat associated with each soil type is provided in this map. Soil fertility, pH, drainage and texture are important factors in determining the types of habitats which can be established. Elevation above sea level and sometimes even the aspect, the orientation of a hillslope, can affect the species present. This map does not take into account the recent land management, but provides the likely natural habitats assuming good management has been carried out.

## 1p Organic Matter (%) in top 30cm



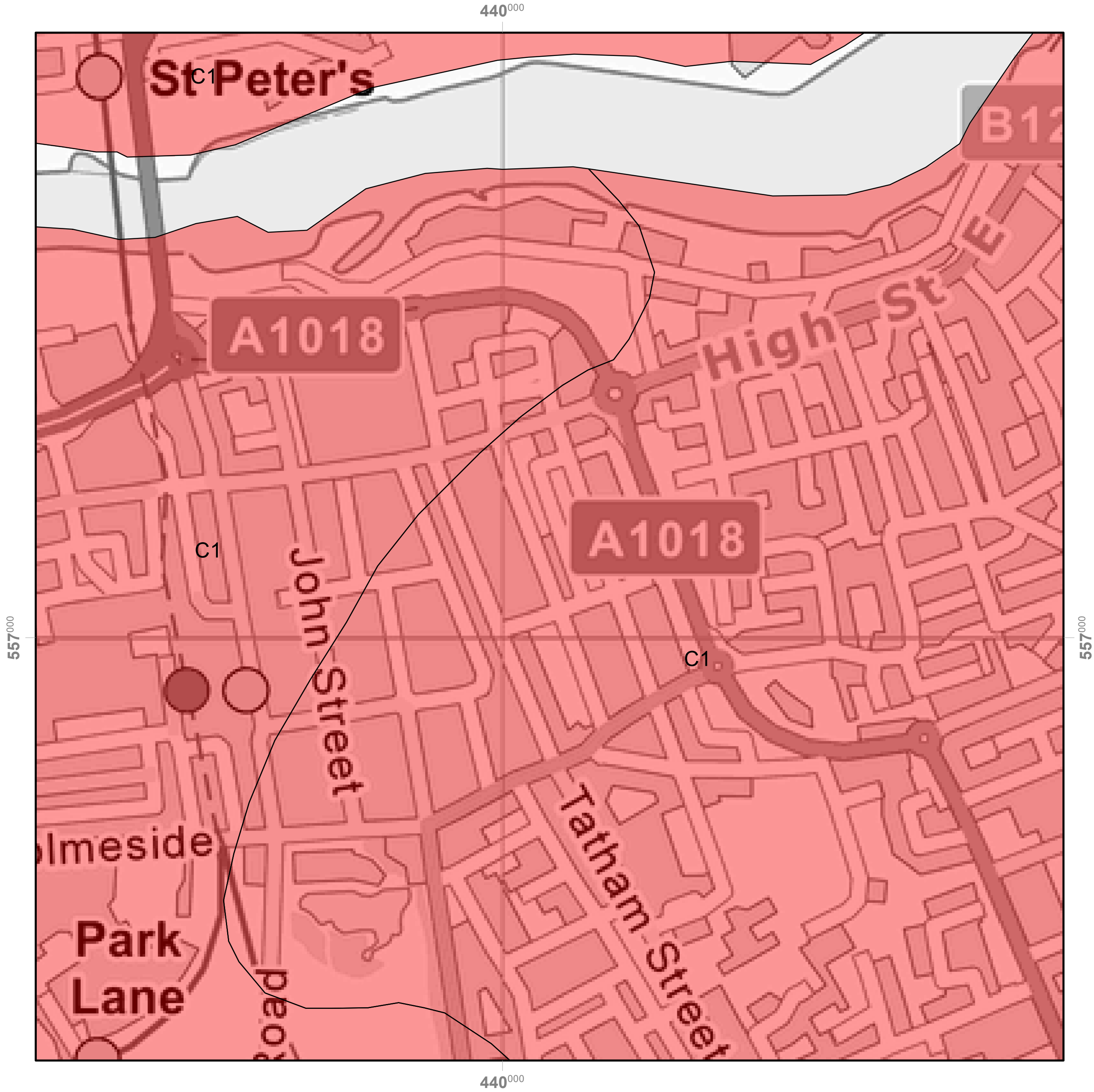
## Organic Matter (%) in top 30cm Key

Unc.

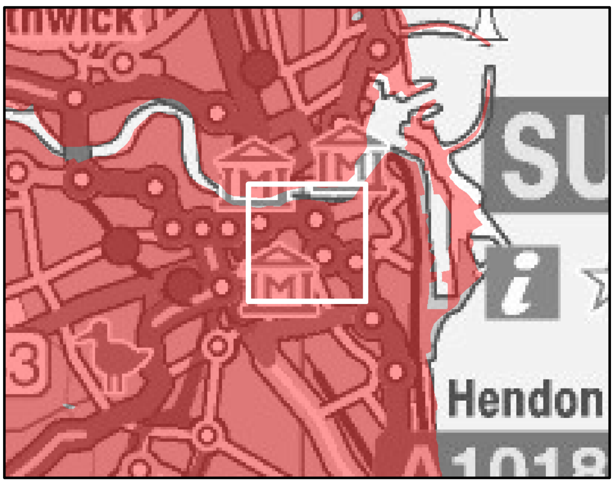
ORGANIC MATTER CONTENT

Average organic matter content in the top 30 cm of the profile. Organic matter averages are based on inherent properties of the soil associations under the main land use types. (Gregory et al. 2014)

# 1q Susceptibility to Compaction





## Susceptibility to Compaction Key

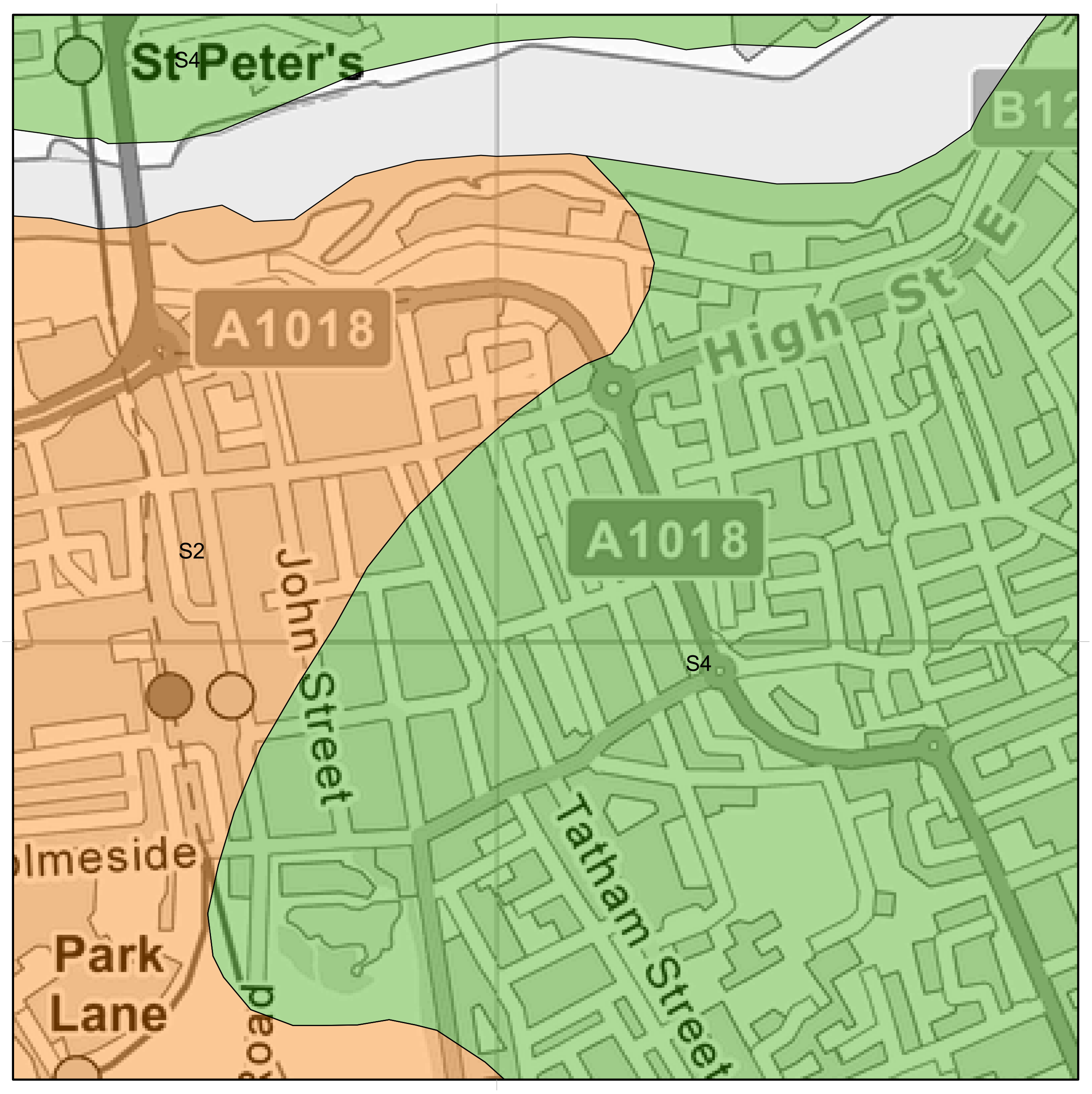
C1 Very Susceptible

SUSCEPTIBILITY TO COMPACTION

The use of heavy machinery such as tractors, trailers, and harvesters can initiate the production of large clods and compaction in topsoils, particularly when field operations are performed when the soil is too wet. Compaction can have many detrimental effects on crop performance and yield as well as environmental sustainability. The effects of compaction include: poor germination and seedling emergence, impeded drainage, waterlogging, and therefore anaerobic conditions all leading to increases in susceptibility of the crop and root to diseases and pests, and soil erosion (with impacts onsite in terms of soil loss as well as offsite sedimentation problems and transport of soil associated pollutants).

Susceptibility to compaction in the topsoil and layers immediately below it is principally determined by clay content and soil wetness, but modified by the presence of calcium carbonate, high organic matter content (organic-mineral or peaty textures) and slowly permeable subsoil layers. Soils most susceptible to compaction are non-calcareous with moderate to high clay contents, a slowly permeable subsoil and wet conditions within 70 cm of the surface for at least 180 days in most years (wetness class III and IV). (Cranfield University, 2001)

# 1r Susceptibility to Topsoil Slaking




## Susceptibility to Topsoil Slaking Key

S2 Unstable

S4 Stable

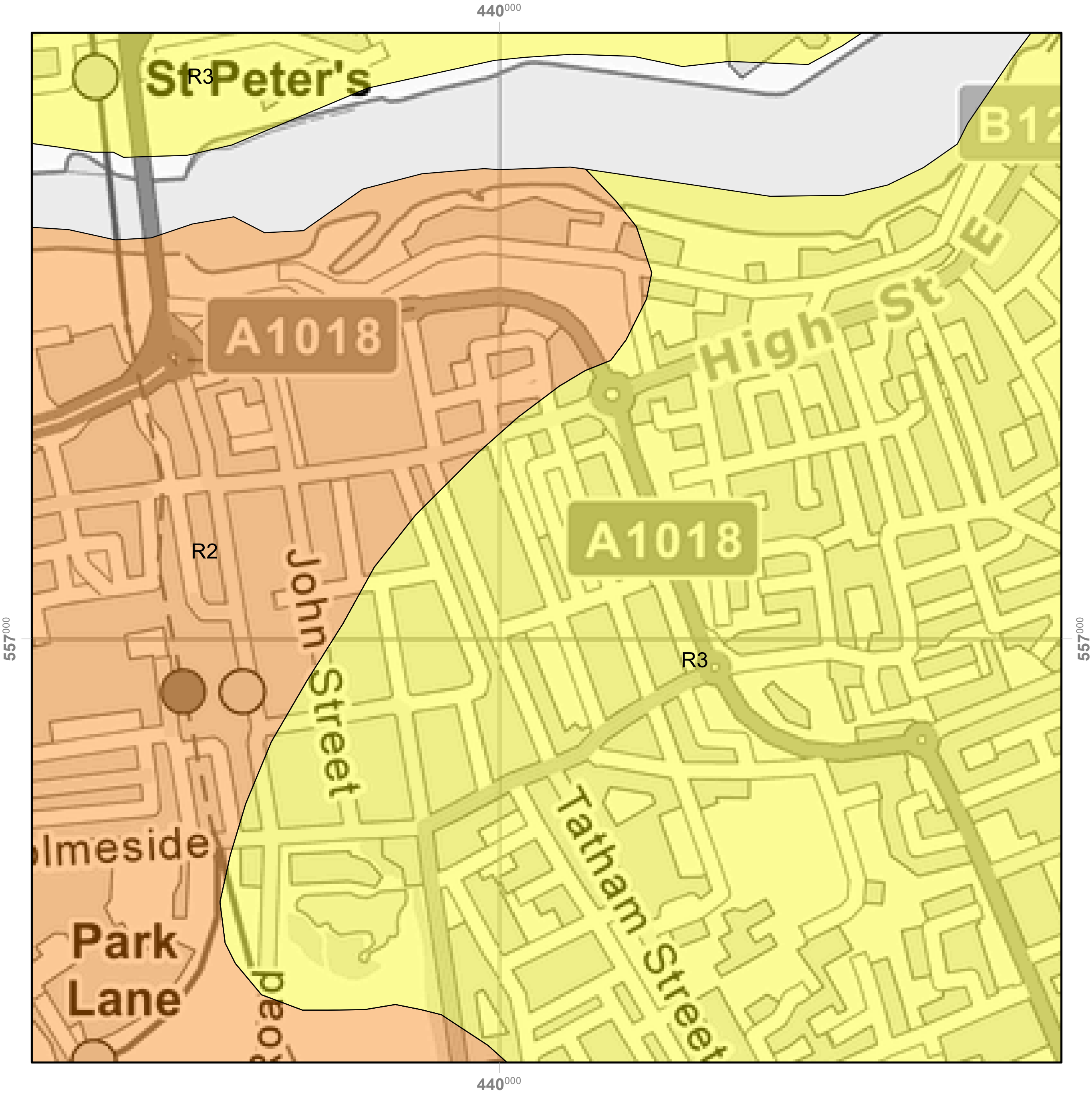
SUSCEPTIBILITY TO TOPSOIL SLAKING

Rain falling on a fine surface layer of an unstable soil can destroy aggregates leading to a dense cap forming on the soil surface. Surface capping can prevent or reduce seedling emergence, reduce infiltration and increase surface runoff.

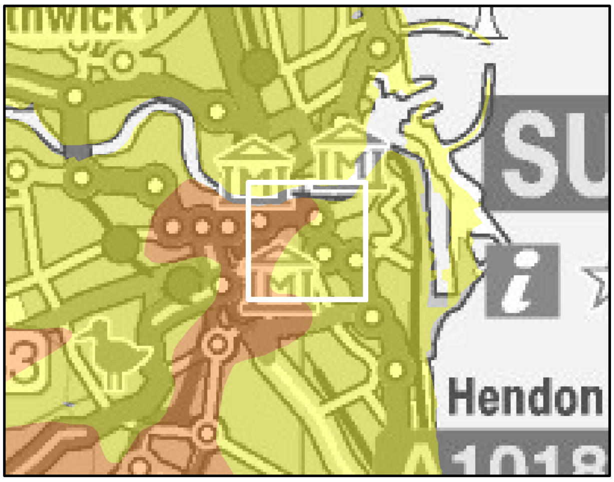
Cultivation practices can alter the structure of the soil via a number of mechanisms. First, cultivation practices can physically loosen or consolidate both top and sub soils improving or degrading structure. In soils containing low organic matter, calcium carbonate and clay cultivation can lead to surface capping, slaking and panning under machinery.

Second, cultivation practices can determine the structural stability of the soil by changing the relative levels of the key factors associated with formation and stability of aggregates. For example, the cultivation of crops often reduces the plant residues that are returned to the soil, lowering the organic matter content and therefore aggregate formation and stability. In addition, the physical effects of cultivation in breaking apart aggregates can serve to expose temporary and transient organic matter to microbial attack, reducing aggregate stability and the likelihood of aggregate formation. (Cranfield University, 2001)

# 1s Natural recovery of structure after compaction





## Natural recovery of structure after compaction Key

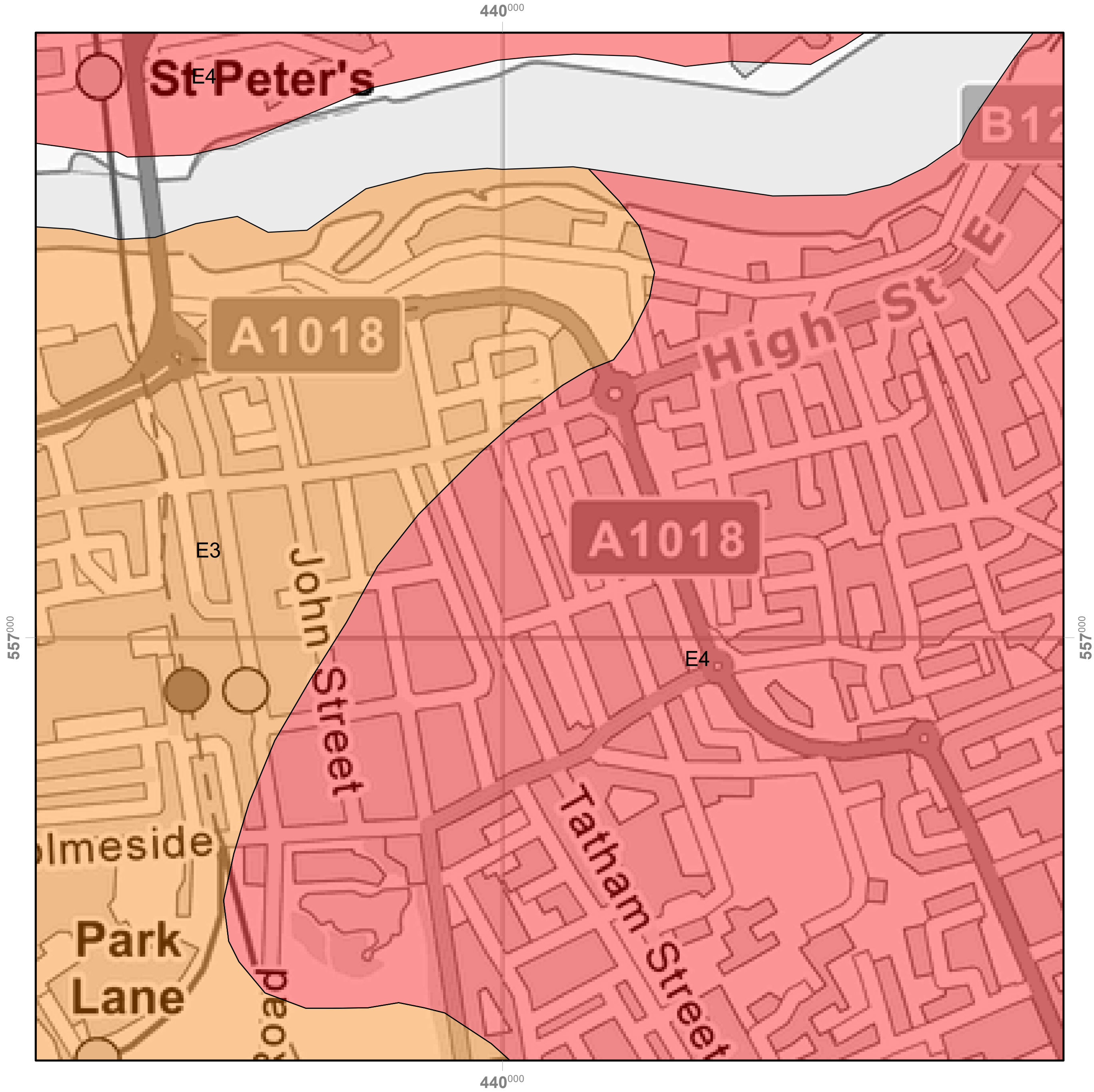
R2 Slight Potential

R3 Potential

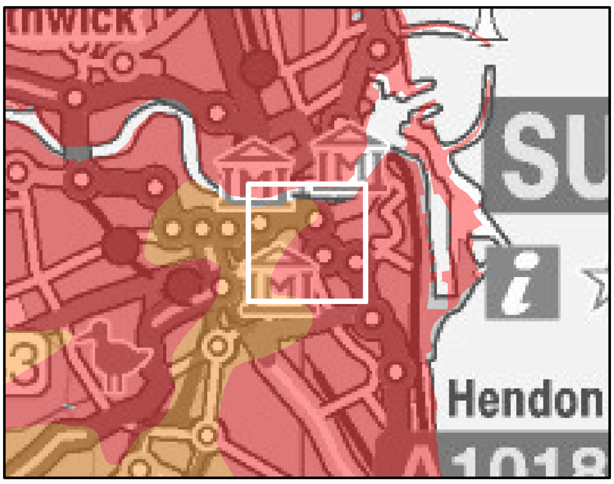
STRUCTURE: POTENTIAL FOR NATURAL RECOVERY FOLLOWING COMPACTION

Soil structure damage can slowly improve through the natural restructuring of soils. This natural recovery and regeneration of soil structure is governed by the same set of factors responsible for formation and stability (that is, organic matter, calcium carbonate, clay content and soil wetness) as well as the processes that drive aggregate formation and structural development (such as freezing and thawing, and biological activities). (Cranfield University, 2001)

## 1t Mechanical rectification of compaction





## Mechanical rectification of compaction Key

E3 Moderately Difficult

E4 Difficult

STRUCTURE: SUCCESS OF MECHANICAL RECTIFICATION OF COMPACTION

Soil structure can be improved through timely cultivations that loosen or consolidate the soil, and sort or reduce clods within the topsoil and/or subsoil levels.

Good soil management and best cultivation practices are paramount at preventing or limiting structural degradation and damage. Initially this would include understanding land capability and selecting the appropriate crops for the land and environmental conditions. A second requirement for good soil structure is to maintain adequate drainage, either natural or artificial. Thirdly, reduced and timely cultivations are of great importance in maintaining good soil structure and preventing damage. Where possible, operations should be limited when the soil is too wet and when most damage is likely to be caused. The considered choice of machinery and equipment such as the use of low ground pressure tyres, tracks or controlled traffic farming can also aid in protecting structure. (Cranfield University, 2001)

# 2. Soil Association Descriptions

The following pages describe the following soil map units, (soil associations), in more detail.

DUNKESWICK 711p
*Slowly permeable seasonally waterlogged fine loamy and fine loamy over clayey soils*

FOGGATHORPE 1 712h
*Slowly permeable seasonally waterlogged clayey and fine loamy over clayey soils, often stoneless.*

The soil associations are described in terms of their texture and drainage properties and potential risks may be identified. The distribution of the soils across England and Wales are provided. Further to this, properties of each association's component soil series are described in relation to each other. Lastly, schematic diagrams of each component series are provided for greater understanding and in-field verification purposes. Further information on the soil associations and soil series can be found at the LandIS Soils Guide

## DUNKESWICK (711p)

*Slowly permeable seasonally waterlogged fine loamy and fine loamy over clayey soils*

### a. General Description

Slowly permeable seasonally waterlogged fine loamy and fine loamy over clayey soilsassociated with similar clayey soils.
The major landuse on this association is defined as Grassland in moist lowlands, some arable cropping in drier lowlands.

### b. Distribution (England and Wales)

The DUNKESWICK association covers 3002 km² of England and Wales which accounts for 1.99% of the landmass. The distribution of this association is shown in figure 2. Note that the yellow shading represents a buffer to highlight the location of very small areas of the association.

### c. Comprising Soil Series

Multiple soil series comprise a soil association. The soil series of the DUNKESWICK association are outlined in Table 1 below. In some cases other minor soil series are present at a particular site, and these have been grouped together under the heading 'OTHER'. We have endeavoured to present the likelihood of a minor, unnamed soil series occuring in your site in Table 1.

Schematic diagrams of the vertical soil profile of the major constituent soil series are provided in Section D to allow easier identification of the particular soil series at your site.

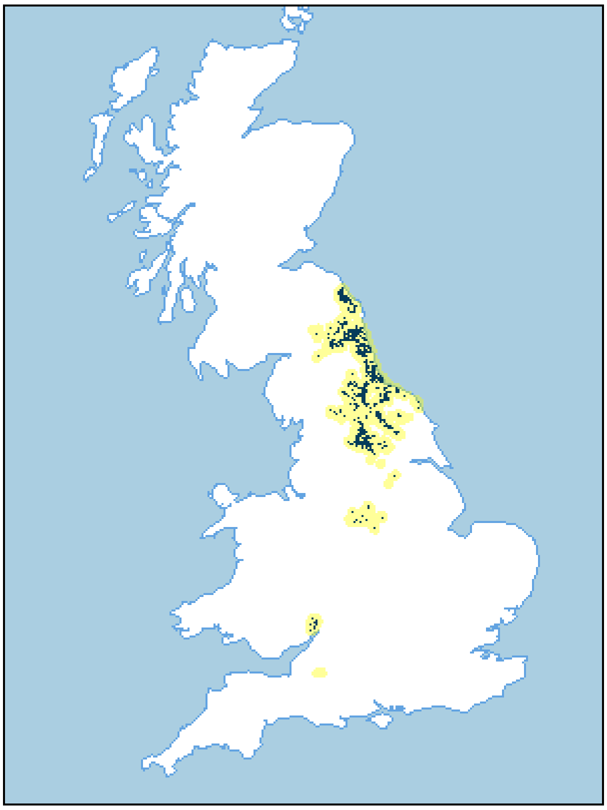


Figure 2: Association Distribution

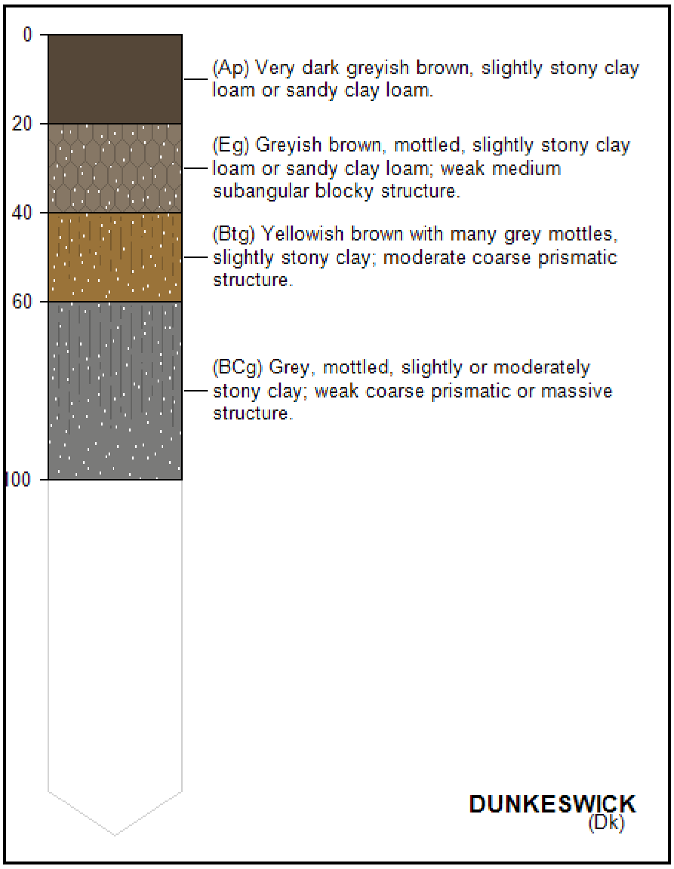
Table 1: The component soil series of the DUNKESWICK soil association. Because absolute proportions of the comprising series in this association vary from location to location, the national proportions are provided.

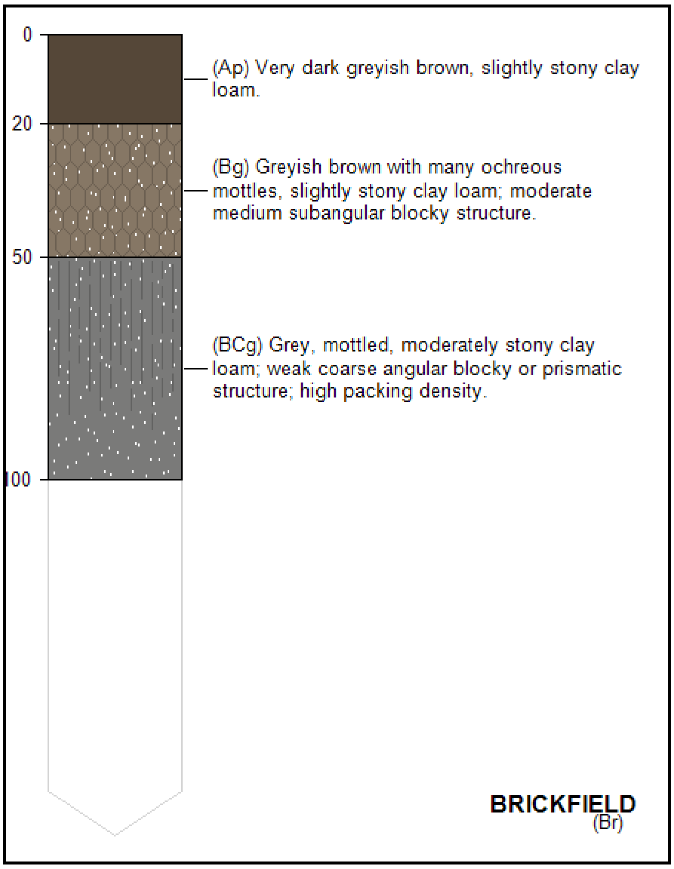
| Soil Series | Description | Area % |
|---|---|---|
| DUNKESWICK (Dk) | medium loamy over clayey drift with siliceous stones | 55% |
| BRICKFIELD (Br) | medium loamy drift with siliceous stones | 25% |
| HALLSWORTH (Hk) | clayey drift with siliceous stones | 10% |
| OTHER | other minor soils | 10% |

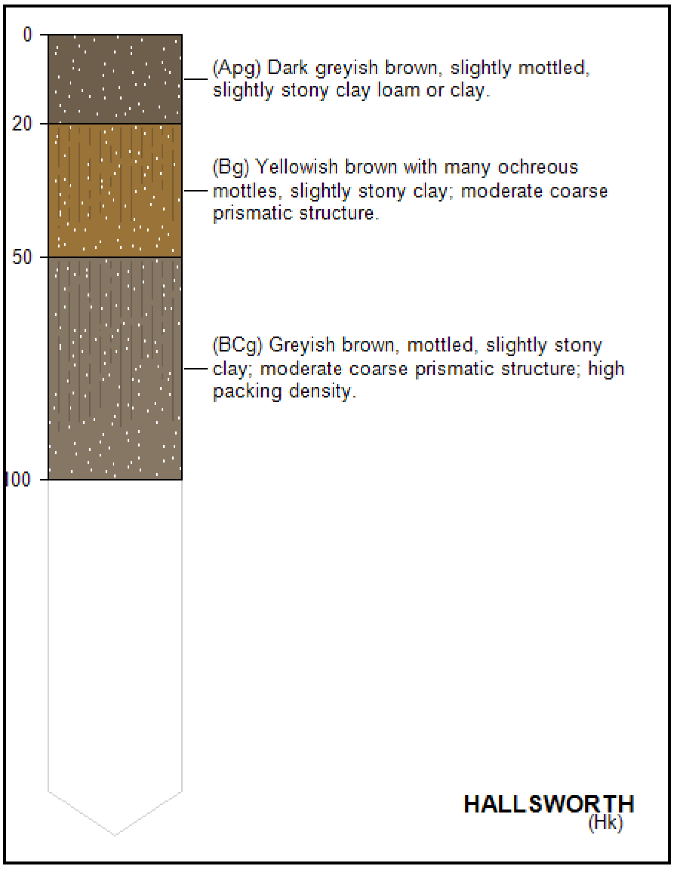
# DUNKESWICK (711p)

*Slowly permeable seasonally waterlogged fine loamy and fine loamy over clayey soils*

## d. DUNKESWICK Component Series Profiles



## FOGGATHORPE 1 (712h)

*Slowly permeable seasonally waterlogged clayey and fine loamy over clayey soils, often stoneless.*

**a. General Description**
Slowly permeable seasonally waterlogged clayey and fine loamy over clayey soils, often stoneless.
The major landuse on this association is defined as Grassland and cereals in Northumberland; dairying on permanent grassland in Wales.

**b. Distribution (England and Wales)**
The FOGGATHORPE 1 association covers 289 km² of England and Wales which accounts for 0.19% of the landmass. The distribution of this association is shown in figure 3. Note that the yellow shading represents a buffer to highlight the location of very small areas of the association.

**c. Comprising Soil Series**
Multiple soil series comprise a soil association. The soil series of the FOGGATHORPE 1 association are outlined in Table 1 below. In some cases other minor soil series are present at a particular site, and these have been grouped together under the heading 'OTHER'. We have endeavoured to present the likelihood of a minor, unnamed soil series occuring in your site in Table 2.

Schematic diagrams of the vertical soil profile of the major constituent soil series are provided in Section D to allow easier identification of the particular soil series at your site.

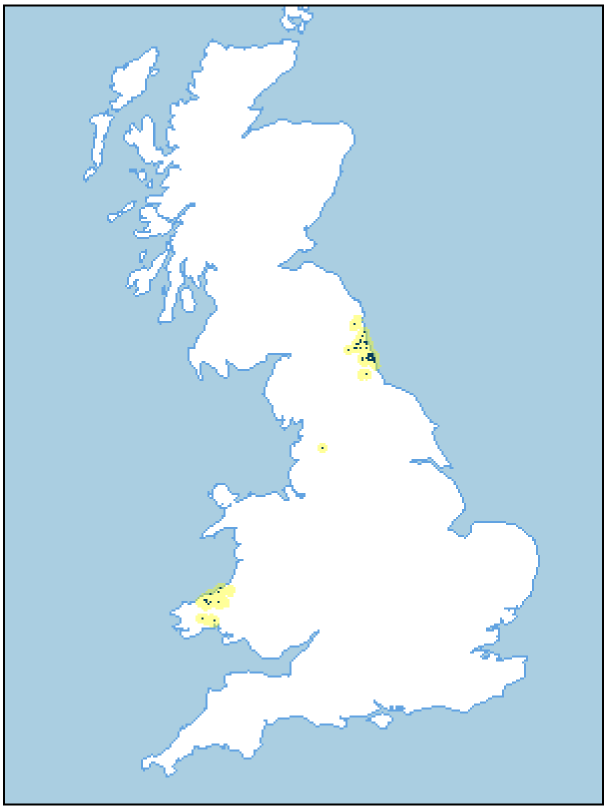


Figure 3: Association Distribution

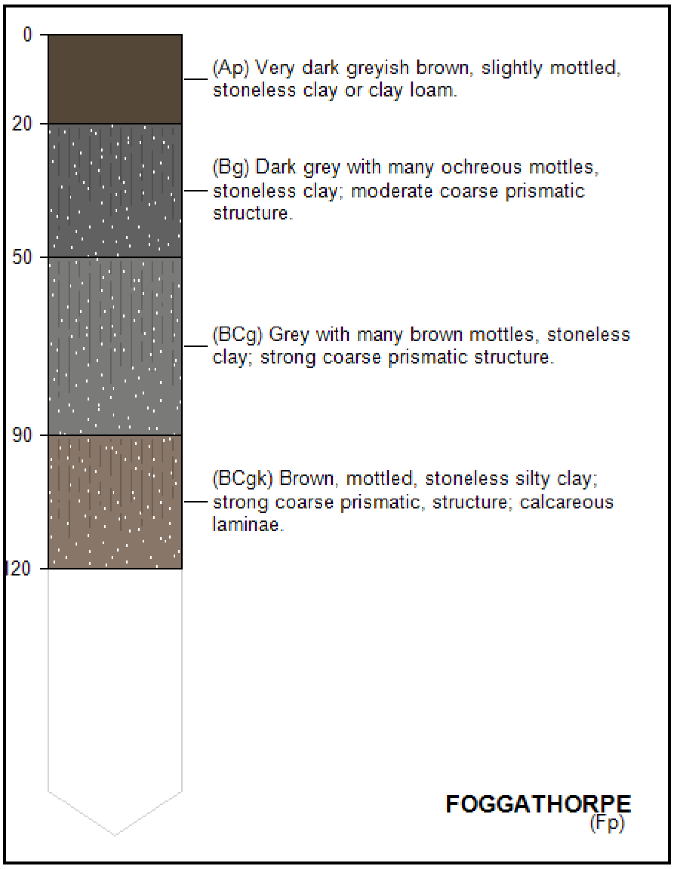
Table 2: The component soil series of the FOGGATHORPE 1 soil association. Because absolute proportions of the comprising series in this association vary from location to location, the national proportions are provided.

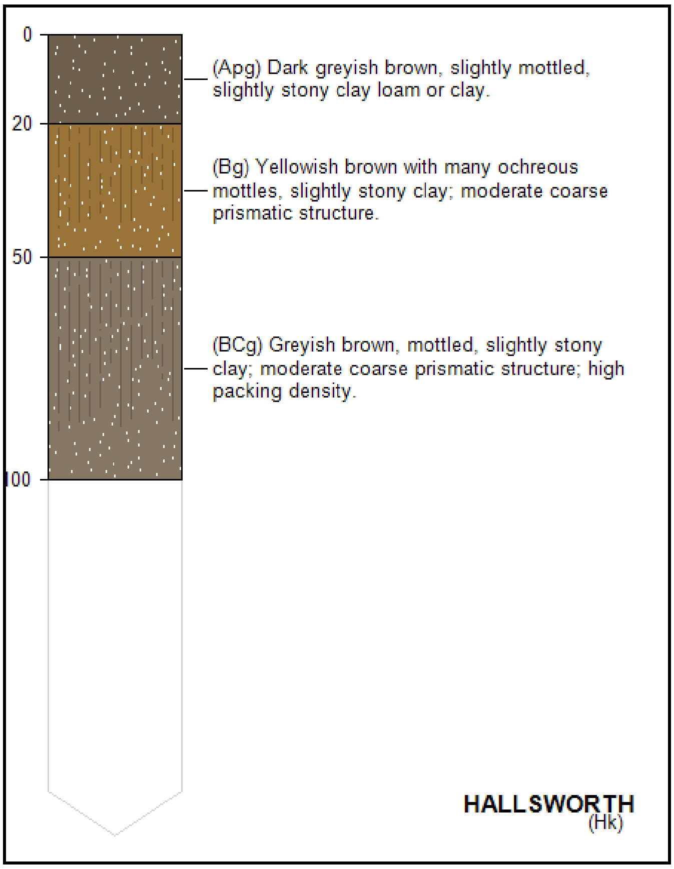
| Soil Series | Description | Area % |
|---|---|---|
| FOGGATHORPE (Fp) | clayey stoneless drift | 50% |
| HALLSWORTH (Hk) | clayey drift with siliceous stones | 30% |
| DUNKESWICK (Dk) | medium loamy over clayey drift with siliceous stones | 20% |

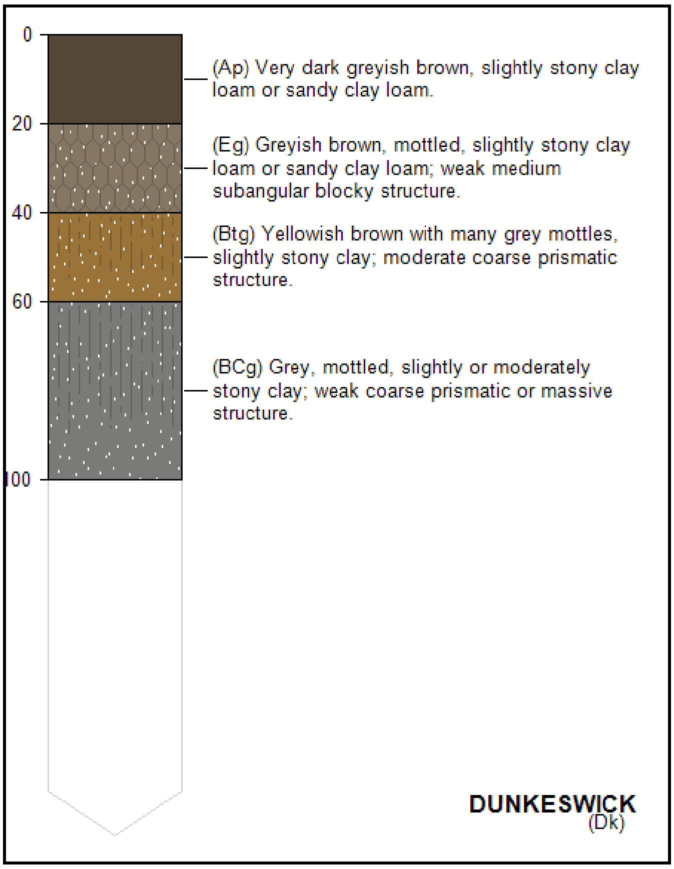
## FOGGATHORPE 1 (712h)

*Slowly permeable seasonally waterlogged clayey and fine loamy over clayey soils, often stoneless.*

### d. FOGGATHORPE 1 Component Series Profiles



# 3. Soil Series Properties

The following pages describe the following soil series in more detail:

| | |
|---|---|
| **BRICKFIELD (Br)** | medium loamy drift with siliceous stones |
| **DUNKESWICK (Dk)** | medium loamy over clayey drift with siliceous stones |
| **FOGGATHORPE (Fp)** | clayey stoneless drift |
| **HALLSWORTH (Hk)** | clayey drift with siliceous stones |

# SOIL PROPERTY DEFINITIONS

The following terms are used in the report.

**DROCK (Depth to rock (cm))**
Depth (cm) to rock. 999 implies no rock

**DGLEY (Depth to gleying (cm))**
Depth to gleyed horizon (cm). 999 implies NO gleyed horizon present.

**DIMP_DP (Depth to slowly permeable layer (downward percolation) (cm))**
Depth (cm) to slowly permeable layer, i.e. in which effectively there is no downward percolation of water - 999 implies NO slowly permeable layer

**DIMP_UD (Depth to slowly permeable layer (upward diffusion) (cm))**
Depth (cm) to slowly permeable layer - upward diffusion, i.e. in which effectively there is no upward movement of water - 999 implies NO slowly permeable layer

**IAC_DP (Integrated air capacity (IAC) (mm))**
Integrated air capacity (downward percolation), a measurement of the volume of air in moist soils (0.05 bar suction) integrated from the surface to either an impermeable horizon, bedrock or 1m whichever is the shallowest, used for estimating the water storage potential of a soil

**SPR (Standard percentage runoff (SPR) (%))**
Standard Percentage Run-off. Dimensionless variable (range 0 to 100 %) that represents the percentage of rainfall that causes the short-term increase in flow at the catchment outlet seen after the storm event

**BFI (Base flow index (BFI) (0 to 1))**
Baseflow index. Dimensionless variable (range 0 to 1) that expresses the fraction of the average flow volume (in a river), represented by the contribution from groundwater storage

**AWC (Available water (AWC) (mm))**
Available water to 1m for a specific soil type, water available between suctions 5 and 1500kPa

**AP_GRASS (Available water for grass (mm))**
Available water (AP) in the profile for grass (mm); water available between suctions 5 and 1500 kPa

**AP_CEREAL (Available water for cereal (mm))**
Available water (AP) in the profile for cereals (mm); water available between suctions 5 and 1500 kPa

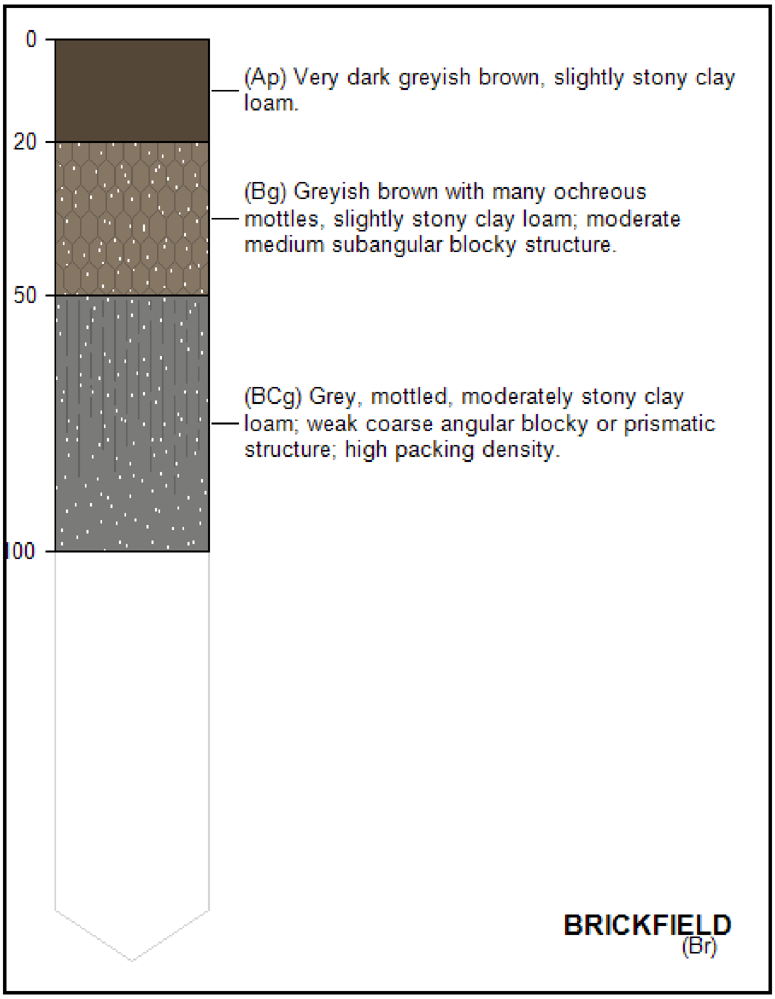
**AP_SB (Available water for sugar (mm))**
Available water (AP) in the profile for sugar beet (mm); water available between suctions 5 and 1500 kPa

**AP_POT (Available water for potatoes (mm))**
Available water (AP) in the profile for potatoes (mm); water available between suctions 5 and 1500 kPa

# 7.13 BRICKFIELD (Br) (142)

| | | |
|---|---|---|
| **Major soil group:** | 07 surface-water gley soils | Seasonally waterlogged slowly permeable soils, formed above 3 m 0.D. and prominently mottled above 40 cm depth. They have no relatively permeable material starting within and extending below 1 m of the surface. |
| **Soil group:** | 1 stagnogley soils | With a distinct topsoil. They are found mainly in lowland Britain. |
| **Soil Subgroup:** | 3 cambic stagnogley soils | (with no clay-enriched subsoil) |
| **Soil Series:** | Brickfield series | medium loamy drift with siliceous stones |

| **Property** | **Value** |
|---|---|
| Depth to rock (cm) | n/a* |
| Depth to gleying (cm) | 25 |
| Depth to slowly permeable layer (downward percolation) (cm) | 34 |
| Depth to slowly permeable layer (upward diffusion) (cm) | 34 |
| Integrated air capacity (IAC) (mm) | 62 |
| Standard percentage runoff (SPR) (%) | 40 |
| Base flow index (BFI) (0 to 1) | 0.31 |
| Available water (AWC) (mm) | 145 |
| Available water for grass (mm) | 130 |
| Available water for cereal (mm) | 135 |
| Available water for sugar (mm) | 165 |
| Available water for potatoes (mm) | 110 |

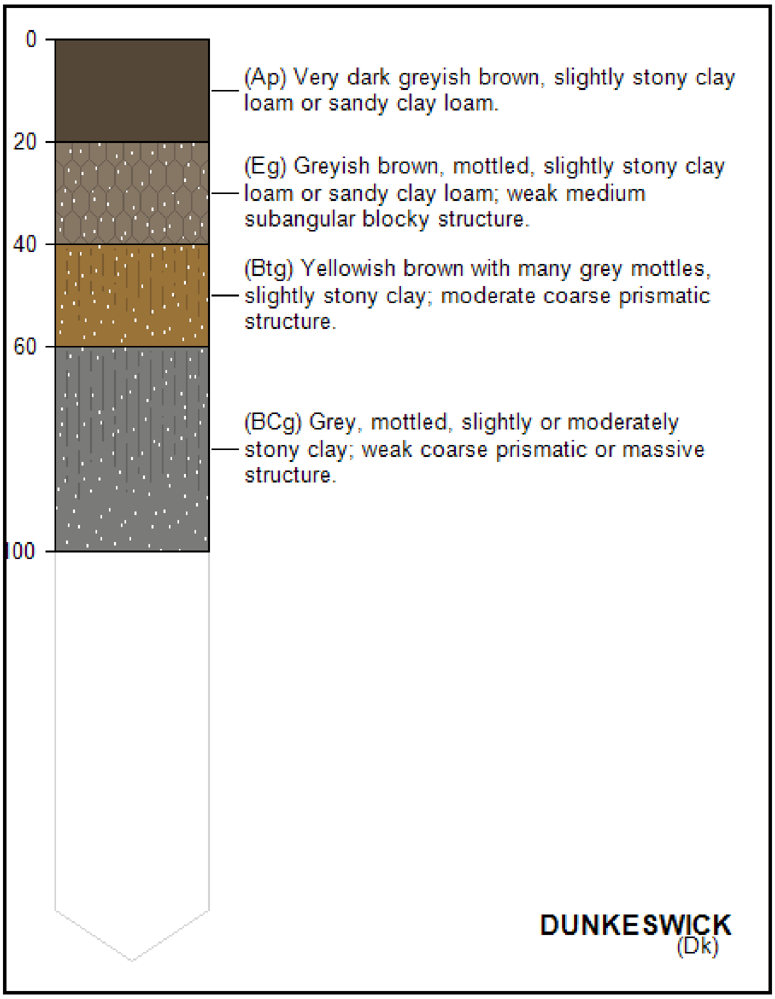



* not present within 150cm

## 7.11 DUNKESWICK (Dk) (321)

| | | |
|---|---|---|
| **Major soil group:** | 07 surface-water gley soils | Seasonally waterlogged slowly permeable soils, formed above 3 m 0.D. and prominently mottled above 40 cm depth. They have no relatively permeable material starting within and extending below 1 m of the surface. |
| **Soil group:** | 1 stagnogley soils | With a distinct topsoil. They are found mainly in lowland Britain. |
| **Soil Subgroup:** | 1 typical stagnogley soils | (with ordinary clay enriched subsoil) |
| **Soil Series:** | Dunkeswick series | medium loamy over clayey drift with siliceous stones |

| **Property** | **Value** |
|---|---|
| Depth to rock (cm) | n/a* |
| Depth to gleying (cm) | 25 |
| Depth to slowly permeable layer (downward percolation) (cm) | 37 |
| Depth to slowly permeable layer (upward diffusion) (cm) | 37 |
| Integrated air capacity (IAC) (mm) | 72 |
| Standard percentage runoff (SPR) (%) | 40 |
| Base flow index (BFI) (0 to 1) | 0.31 |
| Available water (AWC) (mm) | 140 |
| Available water for grass (mm) | 125 |
| Available water for cereal (mm) | 130 |
| Available water for sugar (mm) | 155 |
| Available water for potatoes (mm) | 105 |

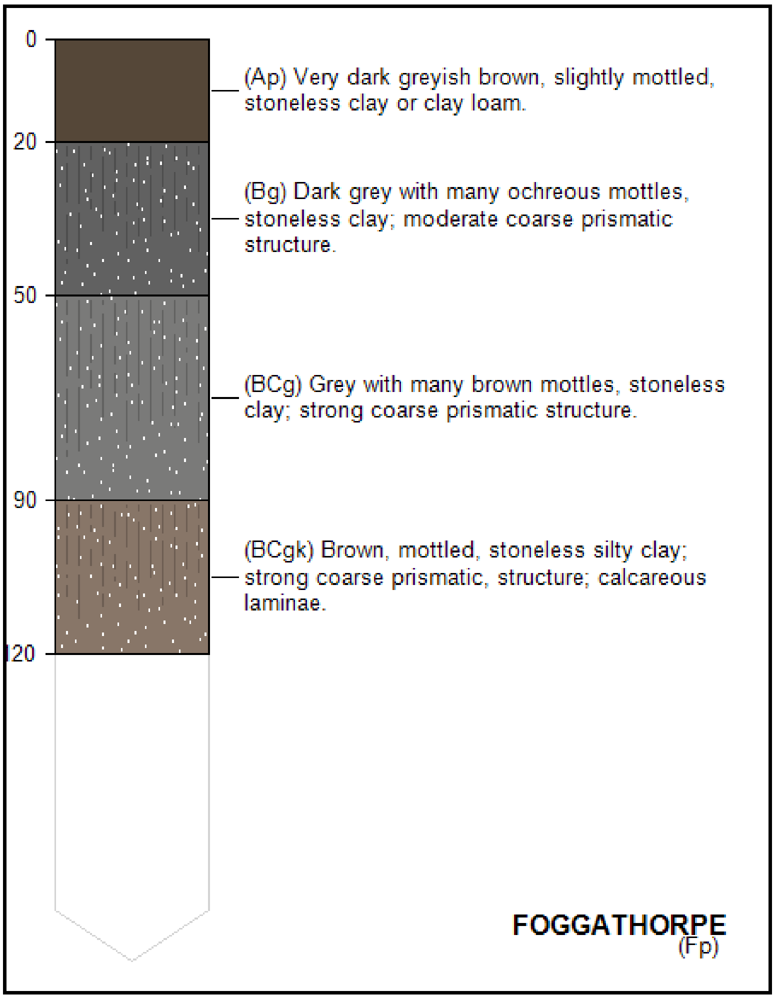



* not present within 150cm

# 7.12 FOGGATHORPE (Fp) (506)

| | | |
|---|---|---|
| **Major soil group:** | 07 surface-water gley soils | Seasonally waterlogged slowly permeable soils, formed above 3 m 0.D. and prominently mottled above 40 cm depth. They have no relatively permeable material starting within and extending below 1 m of the surface. |
| **Soil group:** | 1 stagnogley soils | With a distinct topsoil. They are found mainly in lowland Britain. |
| **Soil Subgroup:** | 2 pelo-stagnogley soils | (clayey) |
| **Soil Series:** | Foggathorpe series | clayey stoneless drift |

| Property | Value |
|---|---|
| Depth to rock (cm) | n/a* |
| Depth to gleying (cm) | 25 |
| Depth to slowly permeable layer (downward percolation) (cm) | 34 |
| Depth to slowly permeable layer (upward diffusion) (cm) | 34 |
| Integrated air capacity (IAC) (mm) | 63 |
| Standard percentage runoff (SPR) (%) | 40 |
| Base flow index (BFI) (0 to 1) | 0.31 |
| Available water (AWC) (mm) | 150 |
| Available water for grass (mm) | 135 |
| Available water for cereal (mm) | 140 |
| Available water for sugar (mm) | 175 |
| Available water for potatoes (mm) | 110 |

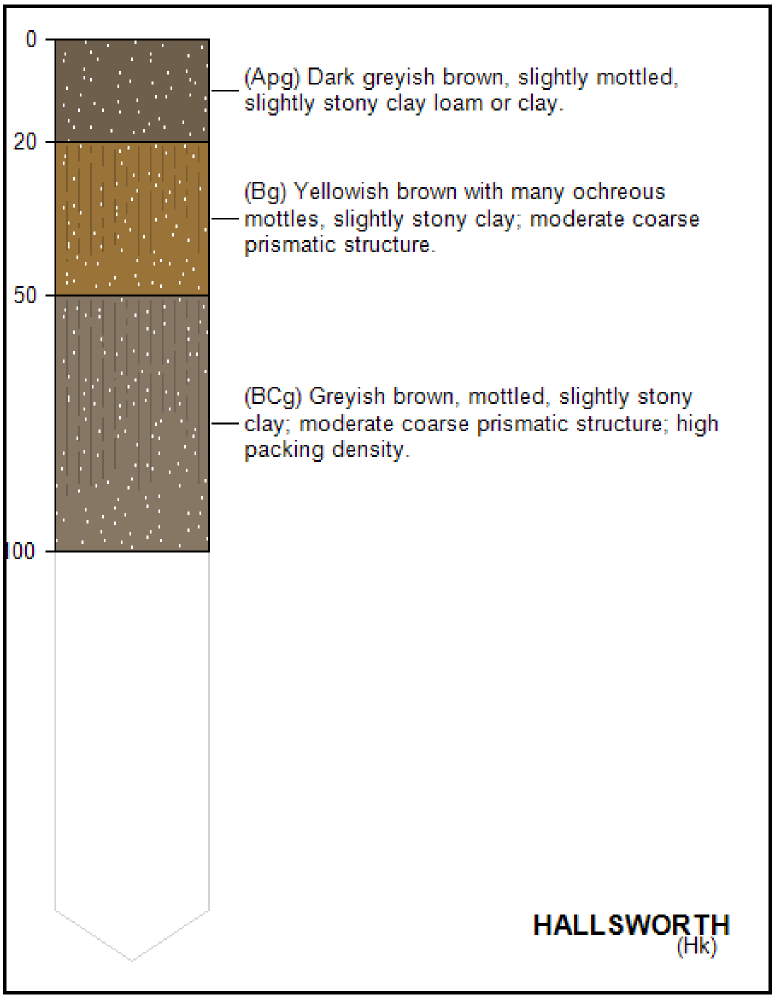



* not present within 150cm

# 7.12 HALLSWORTH (Hk) (702)

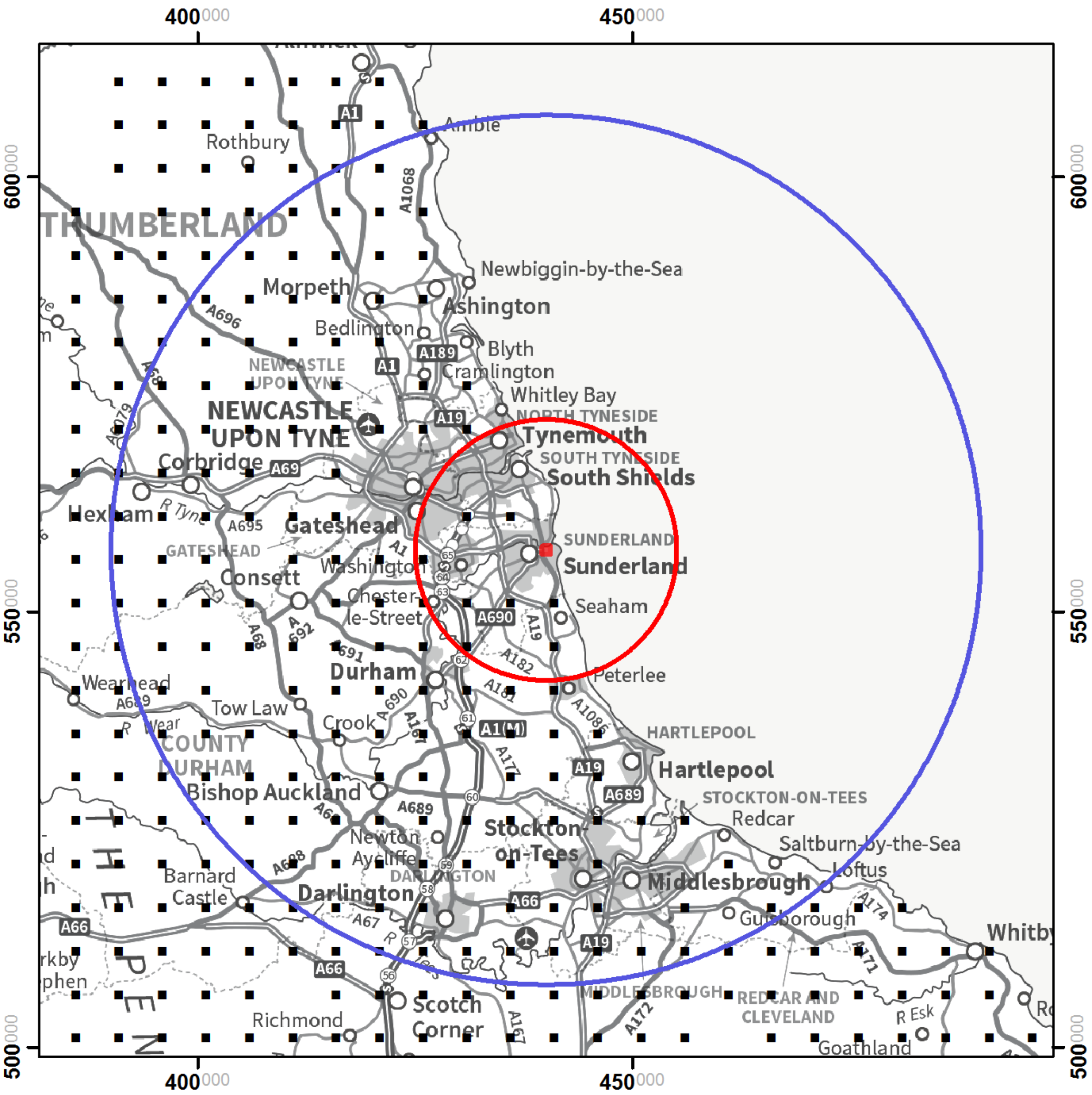
| | | |
|---|---|---|
| **Major soil group:** | 07 surface-water gley soils | Seasonally waterlogged slowly permeable soils, formed above 3 m 0.D. and prominently mottled above 40 cm depth. They have no relatively permeable material starting within and extending below 1 m of the surface. |
| **Soil group:** | 1 stagnogley soils | With a distinct topsoil. They are found mainly in lowland Britain. |
| **Soil Subgroup:** | 2 pelo-stagnogley soils | (clayey) |
| **Soil Series:** | Hallsworth series | clayey drift with siliceous stones |

| **Property** | **Value** |
|---|---|
| Depth to rock (cm) | n/a* |
| Depth to gleying (cm) | 20 |
| Depth to slowly permeable layer (downward percolation) (cm) | 24 |
| Depth to slowly permeable layer (upward diffusion) (cm) | 24 |
| Integrated air capacity (IAC) (mm) | 47 |
| Standard percentage runoff (SPR) (%) | 40 |
| Base flow index (BFI) (0 to 1) | 0.31 |
| Available water (AWC) (mm) | 155 |
| Available water for grass (mm) | 140 |
| Available water for cereal (mm) | 140 |
| Available water for sugar (mm) | 175 |
| Available water for potatoes (mm) | 115 |




* not present within 150cm

# 4. Topsoil Element Background Levels






**Topsoil Element Background Levels Key**

- Report area
- 15 km radius - local area
- 50 km radius - regional area
- NSI sample points

TOPSOIL ELEMENT BACKGROUND LEVELS DESCRIPTION

The National Soil Inventory (NSI) covers England and Wales on a 5 km grid and provides detailed information for each intersect of the grid. Collectively NSI data are statistically representative of England and Wales soils. The original sampling was undertaken around 1980 and there were partial resamplings in the mid-1990s. The most up-to-date data is presented here.

Analysis of the NSI samples provides detailed measurements of over 20 elements from the soils, in addition to pH. This data is summarised over three areas to provide you with an understanding of how your site, and your data for it, sits within the local, regional and national context.

Where available, the soil element levels are compared with the Soil Guideline Values and where a soil sample we have analysed has been found in excess of the SGV guidelines for "residential with plant uptake" land, this is displayed in red in the tables which follow.

SGV levels are provided for the following elements: lead, selenium, nickel, mercury, chromium, cadmium and arsenic.

In the following pages, a number of analyses of the topsoil are provided. The majority of analyses have been performed on the full compliment of sample points, however, in some areas, for some elements, only a few samples were analysed as part of subsequent programmes. In order to present the full suite of possible datasets, and accurately convey the validity of the data, the number of actual measured samples is stated for each analysis. Care should be taken where the number of samples is disproportionately low.

## a. Analysis Within a 15km Radius (8 Sample Points)

| ANALYSES | SAMPLES | MEAN | MIN | MAX | ST.DEV |
|---|---|---|---|---|---|
| pH (PH) | 8 | 6.8 | 4.9 | 7.7 | 1.0 |
| Carbon (CARBON) | 8 | 6.5 | 2.2 | 10.8 | 2.9 |
| Aluminium (AL_ACID) | 8 | 31426.3 | 19034.0 | 38181.0 | 6717.6 |
| Arsenic (AS_ACID) | 8 | 3.0 | 2.0 | 4.0 | 0.8 |
| Barium (BA_ACID) | 8 | 193.1 | 125.0 | 278.0 | 51.6 |
| Calcium (CA_ACID) | 8 | 7644.9 | 1159.0 | 29008.0 | 9085.0 |
| Cadmium (CD_ACID) | 8 | 0.8 | 0.3 | 1.0 | 0.2 |
| Cadmium (Extractable) (CD_EDTA) | 8 | 0.3 | 0.2 | 0.3 | 0.1 |
| Cobalt (CO_ACID) | 8 | 11.5 | 9.4 | 14.6 | 2.0 |
| Cobalt (Extractable) (CO_EDTA) | 8 | 1.2 | 0.1 | 2.1 | 0.6 |
| Chromium (CR_ACID) | 8 | 43.3 | 25.3 | 61.7 | 11.4 |
| Copper (CU_ACID) | 8 | 34.6 | 19.3 | 64.2 | 16.2 |
| Copper (Extractable) (CU_EDTA) | 8 | 11.1 | 4.8 | 24.7 | 7.2 |
| Fluoride (F_ACID) | 8 | 49.2 | 25.7 | 67.3 | 15.2 |
| Iron (FE_ACID) | 8 | 30978.1 | 25483.0 | 34748.0 | 3479.5 |
| Mercury (HG_ACID) | 5 | 0.2 | 0.0 | 0.6 | 0.3 |
| Potassium (K_ACID) | 8 | 4567.6 | 2917.0 | 6149.0 | 1176.3 |
| Potassium (Extractable) (K_NITRATE) | 8 | 115.4 | 79.0 | 178.0 | 42.9 |
| Magnesium (MG_ACID) | 8 | 3328.8 | 1531.0 | 5009.0 | 1090.8 |
| Magnesium (Extractable) (MG_NITRATE) | 8 | 238.4 | 71.0 | 390.0 | 110.7 |
| Manganese (MN_ACID) | 8 | 649.3 | 286.0 | 998.0 | 217.4 |
| Manganese (Extractable) (MN_EDTA) | 8 | 151.9 | 27.0 | 261.0 | 78.7 |
| Molybdenum (MO_ACID) | 8 | 1.2 | 0.6 | 1.6 | 0.4 |
| Sodium (NA_ACID) | 8 | 270.0 | 173.0 | 352.0 | 64.4 |
| Nickel (NI_ACID) | 8 | 28.2 | 21.0 | 35.0 | 5.0 |
| Nickel (Extractable) (NI_EDTA) | 8 | 1.7 | 0.6 | 2.6 | 0.7 |
| Phosphorus (P_ACID) | 8 | 619.9 | 431.0 | 979.0 | 225.4 |
| Phosphorus (Extractable) (P_OLSEN) | 8 | 12.5 | 5.0 | 31.0 | 9.7 |
| Lead (PB_ACID) | 8 | 73.3 | 46.0 | 122.0 | 25.8 |
| Lead (Extractable) (PB_EDTA) | 8 | 29.3 | 13.4 | 54.0 | 13.9 |
| Selenium (SE_ACID) | 8 | 0.6 | 0.0 | 1.2 | 0.4 |
| Strontium (SR_ACID) | 8 | 29.0 | 18.0 | 48.0 | 11.2 |
| Vanadium (V_ACID) | 8 | 42.7 | 28.0 | 64.7 | 14.4 |
| Zinc (ZN_ACID) | 8 | 122.8 | 101.0 | 186.0 | 29.9 |
| Zinc (Extractable) (ZN_EDTA) | 8 | 10.1 | 3.8 | 21.0 | 5.4 |

for units, see Analyses Denitions (p59)

## b. Analysis Within a 50km Radius (142 Sample Points)

| ANALYSES | SAMPLES | MEAN | MIN | MAX | ST.DEV |
|---|---|---|---|---|---|
| pH (PH) | 141 | 5.9 | 3.5 | 7.9 | 1.1 |
| Carbon (CARBON) | 142 | 5.2 | 0.2 | 35.8 | 4.7 |
| Aluminium (AL_ACID) | 142 | 26919.7 | 1932.0 | 60850.0 | 9413.8 |
| Arsenic (AS_ACID) | 112 | 3.1 | 0.0 | 18.0 | 3.1 |
| Barium (BA_ACID) | 142 | 180.7 | 16.0 | 618.0 | 103.1 |
| Calcium (CA_ACID) | 142 | 5648.8 | 118.0 | 221865.0 | 20119.2 |
| Cadmium (CD_ACID) | 142 | 0.6 | 0.0 | 5.8 | 0.6 |
| Cadmium (Extractable) (CD_EDTA) | 142 | 0.3 | 0.1 | 3.6 | 0.3 |
| Cobalt (CO_ACID) | 142 | 9.1 | 0.6 | 19.6 | 4.1 |
| Cobalt (Extractable) (CO_EDTA) | 142 | 1.0 | 0.1 | 2.7 | 0.6 |
| Chromium (CR_ACID) | 142 | 35.1 | 5.3 | 208.4 | 20.8 |
| Copper (CU_ACID) | 142 | 20.9 | 3.7 | 107.3 | 15.5 |
| Copper (Extractable) (CU_EDTA) | 142 | 6.3 | 1.1 | 24.7 | 4.8 |
| Fluoride (F_ACID) | 116 | 157.9 | 13.4 | 6307.9 | 813.7 |
| Iron (FE_ACID) | 142 | 27569.1 | 3207.0 | 102674.0 | 13007.8 |
| Mercury (HG_ACID) | 59 | 0.1 | 0.0 | 0.6 | 0.1 |
| Potassium (K_ACID) | 142 | 3757.0 | 410.0 | 8389.0 | 1704.1 |
| Potassium (Extractable) (K_NITRATE) | 140 | 130.5 | 15.0 | 958.0 | 119.9 |
| Magnesium (MG_ACID) | 142 | 2586.3 | 216.0 | 16700.0 | 1981.3 |
| Magnesium (Extractable) (MG_NITRATE) | 140 | 235.7 | 21.0 | 775.0 | 154.8 |
| Manganese (MN_ACID) | 142 | 642.2 | 21.0 | 2146.0 | 422.0 |
| Manganese (Extractable) (MN_EDTA) | 142 | 159.5 | 5.0 | 743.0 | 120.2 |
| Molybdenum (MO_ACID) | 138 | 0.8 | 0.0 | 6.4 | 0.9 |
| Sodium (NA_ACID) | 142 | 226.7 | 42.0 | 1698.0 | 173.1 |
| Nickel (NI_ACID) | 142 | 23.4 | 0.0 | 110.7 | 14.7 |
| Nickel (Extractable) (NI_EDTA) | 142 | 1.5 | 0.3 | 4.9 | 0.8 |
| Phosphorus (P_ACID) | 142 | 567.7 | 157.0 | 1161.0 | 210.1 |
| Phosphorus (Extractable) (P_OLSEN) | 139 | 17.8 | 1.0 | 126.0 | 17.3 |
| Lead (PB_ACID) | 142 | 118.0 | 19.0 | 3697.0 | 331.3 |
| Lead (Extractable) (PB_EDTA) | 142 | 60.7 | 3.1 | 3185.0 | 270.3 |
| Selenium (SE_ACID) | 112 | 0.6 | 0.0 | 5.3 | 0.6 |
| Strontium (SR_ACID) | 142 | 33.2 | 0.0 | 1295.0 | 107.9 |
| Vanadium (V_ACID) | 139 | 42.5 | 2.3 | 111.6 | 21.1 |
| Zinc (ZN_ACID) | 142 | 101.6 | 17.0 | 1525.0 | 133.8 |
| Zinc (Extractable) (ZN_EDTA) | 142 | 11.8 | 1.1 | 400.3 | 34.2 |

for units, see Analyses Denitions (p59)

## c. National Analysis (5686 Sample Points)

| ANALYSES | SAMPLES | MEAN | MIN | MAX | ST.DEV |
|---|---|---|---|---|---|
| pH (PH) | 5630 | 6.0 | 3.1 | 9.2 | 1.3 |
| Carbon (CARBON) | 5672 | 6.1 | 0.1 | 61.5 | 8.9 |
| Aluminium (AL_ACID) | 5677 | 26775.3 | 491.0 | 79355.0 | 12772.2 |
| Arsenic (AS_ACID) | 2729 | 4.6 | 0.0 | 110.0 | 5.7 |
| Barium (BA_ACID) | 5677 | 150.0 | 7.0 | 3840.0 | 159.5 |
| Calcium (CA_ACID) | 5677 | 13768.7 | 0.0 | 339630.0 | 37785.0 |
| Cadmium (CD_ACID) | 5677 | 0.7 | 0.0 | 40.9 | 1.0 |
| Cadmium (Extractable) (CD_EDTA) | 5655 | 0.5 | 0.0 | 85.0 | 3.0 |
| Cobalt (CO_ACID) | 5677 | 10.6 | 0.0 | 567.0 | 13.7 |
| Cobalt (Extractable) (CO_EDTA) | 5655 | 1.1 | 0.0 | 26.5 | 1.2 |
| Chromium (CR_ACID) | 5677 | 38.9 | 0.0 | 2339.8 | 43.7 |
| Copper (CU_ACID) | 5677 | 22.6 | 0.0 | 1507.7 | 36.8 |
| Copper (Extractable) (CU_EDTA) | 5655 | 6.4 | 0.3 | 431.4 | 11.1 |
| Fluoride (F_ACID) | 3320 | 58.5 | 0.0 | 6307.9 | 186.2 |
| Iron (FE_ACID) | 5677 | 28147.8 | 395.0 | 264405.0 | 16510.5 |
| Mercury (HG_ACID) | 2159 | 0.1 | 0.0 | 2.4 | 0.2 |
| Potassium (K_ACID) | 5677 | 4727.7 | 60.0 | 23905.0 | 2700.2 |
| Potassium (Extractable) (K_NITRATE) | 5609 | 182.0 | 6.0 | 2776.0 | 151.6 |
| Magnesium (MG_ACID) | 5677 | 3648.1 | 0.0 | 62690.0 | 3284.1 |
| Magnesium (Extractable) (MG_NITRATE) | 5609 | 146.0 | 1.0 | 1601.0 | 147.5 |
| Manganese (MN_ACID) | 5677 | 777.0 | 3.0 | 42603.0 | 1068.8 |
| Manganese (Extractable) (MN_EDTA) | 5654 | 159.4 | 0.0 | 3108.0 | 188.6 |
| Molybdenum (MO_ACID) | 4417 | 0.9 | 0.0 | 56.3 | 2.0 |
| Sodium (NA_ACID) | 5677 | 323.3 | 17.0 | 25152.0 | 572.3 |
| Nickel (NI_ACID) | 5677 | 25.4 | 0.0 | 1350.2 | 29.2 |
| Nickel (Extractable) (NI_EDTA) | 5655 | 1.6 | 0.1 | 73.2 | 2.0 |
| Phosphorus (P_ACID) | 5677 | 792.1 | 41.0 | 6273.0 | 433.9 |
| Phosphorus (Extractable) (P_OLSEN) | 5604 | 27.4 | 0.0 | 534.0 | 25.5 |
| Lead (PB_ACID) | 5677 | 73.3 | 0.0 | 17365.0 | 280.6 |
| Lead (Extractable) (PB_EDTA) | 5655 | 27.8 | 1.2 | 6056.5 | 119.7 |
| Selenium (SE_ACID) | 2729 | 0.6 | 0.0 | 22.8 | 0.8 |
| Strontium (SR_ACID) | 5677 | 42.3 | 0.0 | 1445.0 | 67.8 |
| Vanadium (V_ACID) | 4428 | 41.0 | 0.0 | 854.4 | 33.9 |
| Zinc (ZN_ACID) | 5677 | 90.2 | 0.0 | 3648.0 | 104.4 |
| Zinc (Extractable) (ZN_EDTA) | 5655 | 9.6 | 0.5 | 712.0 | 24.6 |

for units, see Analyses Denitions (p59)

# SOIL GUIDELINE VALUES (SGV)

Defra and the Environment Agency have produced soil guideline values (SGVs) as an aid to preliminary assessment of potential risk to human health from land that may be contaminated. SGVs represent 'intervention values', which, if exceeded, act as indicators of potential unacceptable risk to humans, so that more detailed risk assessment is needed.

The SGVs were derived using the Contaminated Land Exposure Assessment (CLEA) model for four land uses:

1. residential (with plant uptake / vegetable growing)
2. residential (without vegetable growing)
3. allotments
4. commercial / industrial

SGVs are only designed to indicate whether further site-specific investigation is needed. Where a soil guideline value is exceeded, it does not mean that there is necessarily a chronic or acute risk to human health.

The values presented in this report represent those from a number of sample points ( given in the "Samples" column in each table) providing local, regional and national background levels. Figures which appear in red indicate that a bulked sample from 20m surrounding a sample point, has at a past date, exceeded the SGV for the 'residential with plant uptake' land use.

It is always advisable to perform site specific investigations.

More details on all the SGVs can be found on the Environment Agency Website.

All units are mg/kg which is equivalent to parts per million (ppm)

| SUBSTANCE | RESIDENTIAL WITH PLANT UPTAKE | RESIDENTIAL WITHOUT PLANT UPTAKE | ALLOTMENTS | COMMERCIAL /INDUSTRIAL |
|---|---|---|---|---|
| LEAD | 450 | 450 | 450 | 750 |
| SELENIUM | 35 | 260 | 35 | 8000 |
| NICKEL | 50 | 75 | 50 | 5000 |
| MERCURY | 8 | 15 | 8 | 450 |
| CHROMIUM | 130 | 200 | 130 | 5000 |
| CADMIUM (pH 6) | 1 | 30 | 1 | 1400 |
| CADMIUM (pH 7) | 2 | 30 | 2 | 1400 |
| CADMIUM (pH 8) | 8 | 30 | 8 | 1400 |
| ARSENIC | 20 | 20 | 20 | 500 |

# ANALYSES DEFINITIONS

**PH (pH)**
pH of soil measure after shaking 10ml of soil for 15 minutes with 25ml of water

**CARBON (Carbon)**
Organic Carbon (% by wt) measured either by loss-on-ignition for soils estimated to contain more than about 20% organic carbon or by dichromate digestion.

**AL_ACID (Aluminium)**
Total Aluminium concentration (mg/kg) determined by Inductively Coupled Plasma Emission Spectrometry (ICP) in an aqua regia digest

**AS_ACID (Arsenic)**
Total Arsenic concentration (mg/kg) determined by Hydride Atomic Absorption Spectrometry (AAS), extracted into hydrochloric acid after digestion with nitric acid and ashing with magnesium nitrate

**BA_ACID (Barium)**
Total Barium concentration (mg/kg) determined by Inductively Coupled Plasma Emission Spectrometry (ICP) in an aqua regia digest

**CA_ACID (Calcium)**
Total Calcium concentration (mg/kg) determined by Inductively Coupled Plasma Emission Spectrometry (ICP) in an aqua regia digest

**CD_ACID (Cadmium)**
Total Cadmium concentration (mg/kg) determined by Inductively Coupled Plasma Emission Spectrometry (ICP) in an aqua regia digest

**CD_EDTA (Cadmium Extractable)**
Extractable Cadmium concentration (mg/l) determined by Inductively Coupled Plasma Emission Spectrometry (ICP) after shaking 10ml of soil with 50ml of 0.05M EDTA at pH 7.0 for 1h at 20 deg. C and then filtering

**CO_ACID (Cobalt)**
Total Cobalt concentration (mg/kg) determined by Inductively Coupled Plasma Emission Spectrometry (ICP) in an aqua regia digest

**CO_EDTA (Cobalt Extractable)**
Extractable Cobalt concentration (mg/l) determined by Inductively Coupled Plasma Emission Spectrometry (ICP) after shaking 10ml of soil with 50ml of 0.05M EDTA at pH 7.0 for 1h at 20 deg. C and then filtering

**CR_ACID (Chromium)**
Total Chromium concentration (mg/kg) determined by Inductively Coupled Plasma Emission Spectrometry (ICP) in an aqua regia digest

**CU_ACID (Copper)**
Total Copper concentration (mg/kg) determined by Inductively Coupled Plasma Emission Spectrometry (ICP) in an aqua regia digest

**CU_EDTA (Copper Extractable)**
Extractable Copper concentration (mg/l) determined by Inductively Coupled Plasma Emission Spectrometry (ICP) after shaking 10ml of soil with 50ml of 0.05M EDTA at pH 7.0 for 1h at 20 deg. C and then filtering

# ANALYSES DEFINITIONS continued

**F_ACID (Flouride)**
Flouride extracted with 1mol / l sulphuric acid and determined by Ion Selective Electrode (ISE)

**FE_ACID (Iron)**
Total Iron concentration (mg/kg) determined by Inductively Coupled Plasma Emission Spectrometry (ICP) in an aqua regia digest

**HG_ACID (Mercury)**
Total Mercury concentration (mg/kg) determined by Hydride Atomic Absorption Spectrometry (AAS), digested in a nitric/sulphuric acid mixture

**K_ACID (Potassium)**
Total Potassium concentration (mg/kg) determined by Inductively Coupled Plasma Emission Spectrometry (ICP) in an aqua regia digest

**K_NITRATE (Potassium Extractable)**
Extractable Potassium concentration (mg/l) determined by shaking 10ml of air dry soil with 50ml of 1.0M ammonium nitrate for 30mins, filtering and then measuring the concentration by flame photometry

**MG_ACID (Magnesium)**
Total Magnesium concentration (mg/kg) determined by Inductively Coupled Plasma Emission Spectrometry (ICP) in an aqua regia digest

**MG_NITRATE (Magnesium Extractable)**
Extractable Magnesium concentration (mg/l) determined by shaking 10ml of air dry soil with 50ml of 1.0M ammonium nitrate for 30mins, filtering and then measuring the concentration by flame photometry

**MN_ACID (Manganese)**
Total Manganese concentration (mg/kg) determined by Inductively Coupled Plasma Emission Spectrometry (ICP) in an aqua regia digest

**MN_EDTA (Manganese Extractable)**
Extractable Manganese concentration (mg/l) determined by Inductively Coupled Plasma Emission Spectrometry (ICP) after shaking 10ml of soil with 50ml of 0.05M EDTA at pH 7.0 for 1h at 20 deg. C and then filtering

**MO_ACID (Molybdenum)**
Total Molybdenum concentration (mg/kg) determined by Atomic Adsorption Spectrometyr (AAS) in an aqua regia digest

**MO_EDTA (Molybdenum Extractable)**
Extractable Molybdenum concentration (mg/l) determined by Inductively Coupled Plasma Emission Spectrometry (ICP) after shaking 10ml of soil with 50ml of 0.05M EDTA at pH 7.0 for 1h at 20 deg. C and then filtering

**NA_ACID (Sodium)**
Total Sodium concentration (mg/kg) determined by Inductively Coupled Plasma Emission Spectrometry (ICP) in an aqua regia digest

**NI_ACID (Nickel)**
Total Nickel concentration (mg/kg) determined by Inductively Coupled Plasma Emission Spectrometry (ICP) in an aqua regia digest

# ANALYSES DEFINITIONS continued

**NI_EDTA (Nickel Extractable)**
Extractable Nickel concentration (mg/l) determined by Inductively Coupled Plasma Emission Spectrometry (ICP) after shaking 10ml of soil with 50ml of 0.05M EDTA at pH 7.0 for 1h at 20 deg. C and then filtering

**P_ACID (Phosphorus)**
Total Phosphorus concentration (mg/kg) determined by Inductively Coupled Plasma Emission Spectrometry (ICP) in an aqua regia digest

**P_OLSON (Phosphorous Extractable)**
Extractable Phosphorus concentration (mg/l) determined by shaking 5ml of air dry soil with 100ml of 0.5M sodium bicarbonate for 30mins at 20 deg.C, filtering and then measuring the absorbance at 880 nm colorimetrically with acid ammonium molybdate solution

**PB_ACID (Lead)**
Total Lead concentration (mg/kg) determined by Inductively Coupled Plasma Emission Spectrometry (ICP) in an aqua regia digest

**PB_EDTA (Lead Extractable)**
Extractable Lead concentration (mg/l) determined by Inductively Coupled Plasma Emission Spectrometry (ICP) after shaking 10ml of soil with 50ml of 0.05M EDTA at pH 7.0 for 1h at 20 deg. C and then filtering

**SE_ACID (Selenium)**
Total Selenium concentration (mg/kg) determined by Hydride Atomic Absorption Spectrometry (AAS), extracted into hydrochloric acid after digestion with nitric acid and ashing with magnesium nitrate

**SR_ACID (Strontium)**
Total Strontium concentration (mg/kg) determined by Inductively Coupled Plasma Emission Spectrometry (ICP) in an aqua regia digest

**V_ACID (Vanadium)**
Total Vanadium concentration (mg/kg) determined by Atomic Adsorption Spectrometeyr (AAS) in an aqua regia digest

**ZN_ACID (Zinc)**
Total Zinc concentration (mg/kg) determined by Inductively Coupled Plasma Emission Spectrometry (ICP) in an aqua regia digest

**ZN_EDTA (Zinc Extractable)**
Extractable Zinc concentration (mg/l) determined by Inductively Coupled Plasma Emission Spectrometry (ICP) after shaking 10ml of soil with 50ml of 0.05M EDTA at pH 7.0 for 1h at 20 deg. C and then filtering

# REFERENCES

AVERY, B.W. (1973). Soil classification in the Soil Survey of England and Wales. Journal of Soil Science, 24, 324-338.

AVERY, B.W., (1980). Soil classification for England and Wales. Soil Survey Technical Monograph No.14, Harpenden, UK.

BOORMAN, D.B, HOLLIS, J.M. and LILLEY, A. (1995). Hydrology of Soil Types: a hydrologically-based classification of the soils of the UK. Institute of Hydrology Report No.126, Wallingford, UK.

CLAYDEN, B and HOLLIS, J.M. (1984). Critieria for Differentiating Soil Series. Soil Survey Technical Monograph No.17, pp159. Harpenden, UK.

HALLETT, S.H., KEAY, C.A., JARVIS, M.G. and JONES, R.J.A. (1994). INSURE: Subsidence risk assessment from soil and climate data. Proceedings of the Association for Geographic Information (AGI). National Conference Markets for Geographic Information. Birmingham. 16.2.1 - 16.2.7.

HOLLIS, J.M. (1991). Mapping the vulnerability of aquifers and surface waters to pesticide contamination at the national and regional scale. In: Pesticides in Soils and Water, BCPC Monograph No.47, 165-174.

HOLLIS, J.M., KEAY, C.A., HALLETT, S. H., GIBBONS, J.W. and COURT, A.C. (1995). Using CatchIS to assess the risk to water resources from diffusely applied pesticides. In: British Crop Protection Council monograph No. 62: Pesticide movement to water, 345-350

JARVIS, M.G and HEDGES, M.R. (1994). Use of soil maps to predict the incidence of corrosion and the need for iron mains renewal. Journal of the Institution of Water and Environmental Management 8, (1) 68-75.

PALMER, R.C., HOLMAN, I.P., ROBINS, N.S. and LEWIS, M.A. (1995). Guide to groundwater vulnerability mapping in England and Wales. National Rivers Authority R and D Note 578/1/ST.

To view a glossary visit: www.landis.org.uk/sitereporter/glossary.pdf
For a list of further reading visit: www.landis.org.uk/sitereporter/FURTHER_READING.pdf

**GIS Datasets:**
The GIS data used in the creation of this report is available to lease for use in projects.
To learn more about, or acquire the GIS datasets used in the creation of this report, please contact the Nationals Soil Resources Institute:

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Cranfield University
Bedfordshire
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United Kingdom
www.landis.org.uk

## Appendix F: Existing Runoff Rate Calculations

## Simulation Settings

| | | | |
|---|---|---|---|
| Rainfall Methodology | FSR | Drain Down Time (mins) | 240 |
| FSR Region | England and Wales | Additional Storage ($m^3$/ha) | 20.0 |
| M5-60 (mm) | 17.000 | Check Discharge Rate(s) | ✓ |
| Ratio-R | 0.300 | 1 year (l/s) | 28.6 |
| Summer CV | 1.000 | 30 year (l/s) | 70.0 |
| Winter CV | 1.000 | 100 year (l/s) | 90.3 |
| Analysis Speed | Detailed | Check Discharge Volume | x |
| Skip Steady State | x | | |

**Storm Durations**

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

| Return Period (years) | Climate Change (CC %) | Additional Area (A %) | Additional Flow (Q %) |
|---|---|---|---|
| 100 | 45 | 0 | 0 |

## Pre-development Discharge Rate

| | | | |
|---|---|---|---|
| Site Makeup | Brownfield | Time of Concentration (mins) | 15.00 |
| Brownfield Method | MRM | Betterment (%) | 0 |
| Contributing Area (ha) | 0.295 | Q 1 year (l/s) | 28.6 |
| PIMP (%) | 100 | Q 30 year (l/s) | 70.0 |
| CV | 1.000 | Q 100 year (l/s) | 90.3 |

## Simulation Settings

| | | | |
|---|---|---|---|
| Rainfall Methodology | FSR | Drain Down Time (mins) | 240 |
| FSR Region | England and Wales | Additional Storage ($m^3$/ha) | 20.0 |
| M5-60 (mm) | 17.000 | Check Discharge Rate(s) | ✓ |
| Ratio-R | 0.300 | 1 year (l/s) | 1.5 |
| Summer CV | 1.000 | 30 year (l/s) | 3.3 |
| Winter CV | 1.000 | 100 year (l/s) | 4.3 |
| Analysis Speed | Detailed | Check Discharge Volume | x |
| Skip Steady State | x | | |

**Storm Durations**

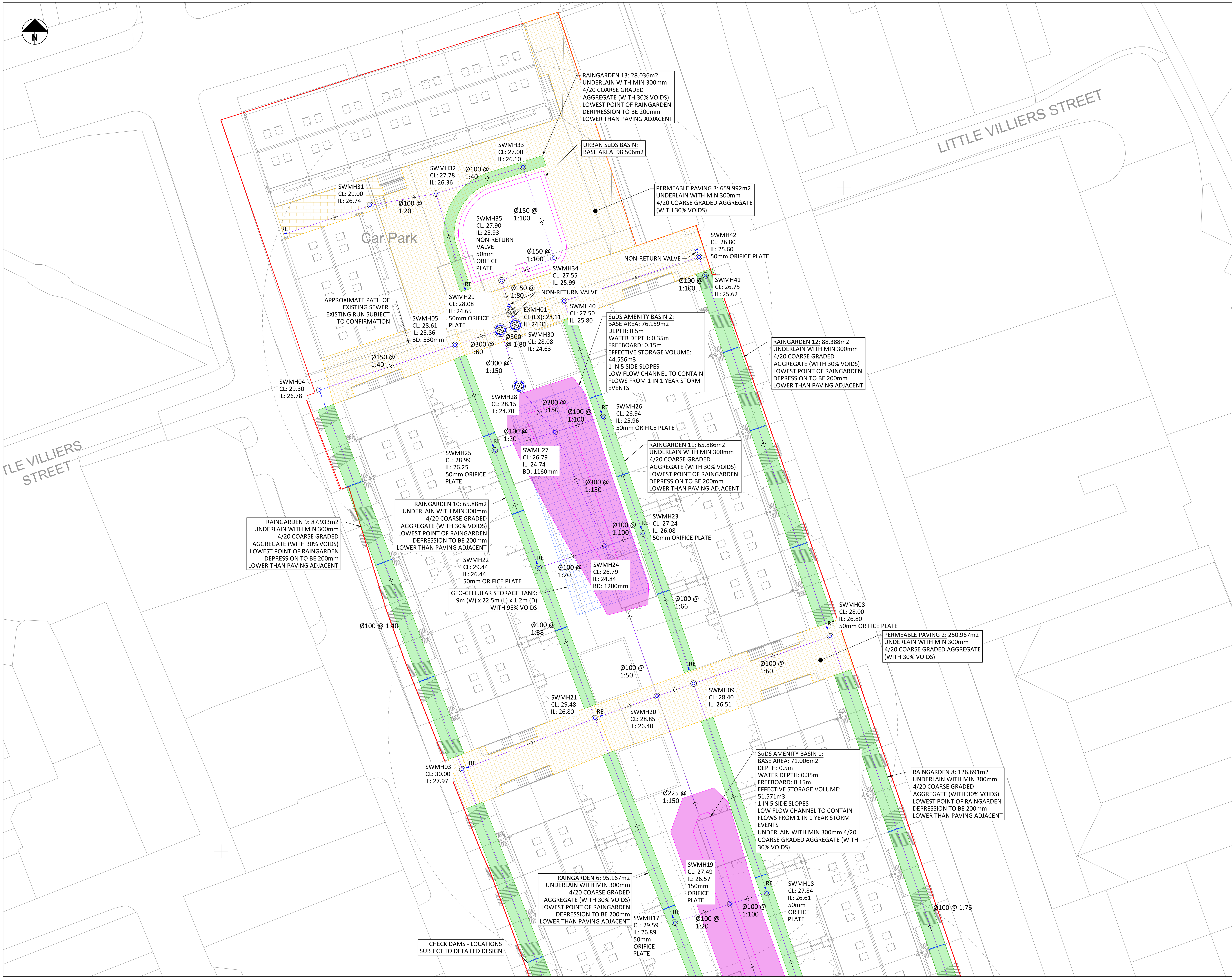
| 15 | 30 | 60 | 120 | 180 | 240 | 360 | 480 | 600 | 720 | 960 | 1440 |
|---|---|---|---|---|---|---|---|---|---|---|---|

| Return Period (years) | Climate Change (CC %) | Additional Area (A %) | Additional Flow (Q %) |
|---|---|---|---|
| 100 | 45 | 0 | 0 |

## Pre-development Discharge Rate

| | | | |
|---|---|---|---|
| Site Makeup | Greenfield | Growth Factor 30 year | 1.95 |
| Greenfield Method | FEH | Growth Factor 100 year | 2.48 |
| Positively Drained Area (ha) | 0.510 | Betterment (%) | 0 |
| SAAR (mm) | 619 | QMed | 1.6 |
| Host | 24 | QBar | 1.7 |
| BFIHost | 0.333 | Q 1 year (l/s) | 1.5 |
| Region | 1 | Q 30 year (l/s) | 3.3 |
| QBar/QMed conversion factor | 1.060 | Q 100 year (l/s) | 4.3 |
| Growth Factor 1 year | 0.85 | | |

## Appendix G: Proposed Surface Water Drainage Layout




FILE LOCATION PATH: P:\PROJECTS HOT\2920 NILE AND VILLIERS, SUNDERLAND\004 BIM\CIVILS\DRAWINGS\2920-CIV-XX-XX-D-C-30001.DWG

STANDARD NOTES

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL RELEVANT ARCHITECT'S AND ENGINEER'S DRAWINGS AND THE SPECIFICATIONS.
2. THIS DRAWING SHOULD NOT BE SCALED.
3. ALL DIMENSIONS ARE TO BE VERIFIED BY THE CONTRACTOR ON SITE.
4. ALL DISCREPANCIES SHOULD BE REPORTED TO C.A./E.A. PRIOR TO THE COMMENCEMENT OF WORKS.

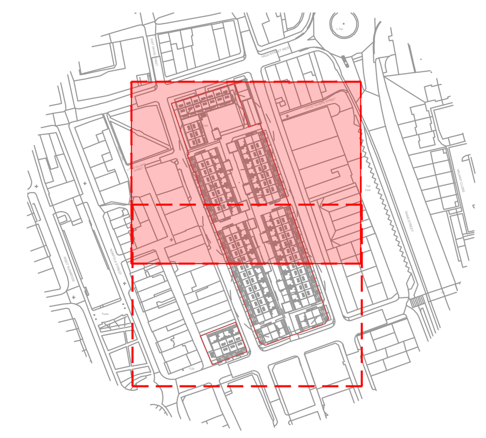


KEY:

- REDLINE BOUNDARY
- PROPOSED SURFACE WATER DRAINAGE
- PROPOSED SURFACE WATER MANHOLE
- PROPOSED SURFACE WATER INSPECTION CHAMBER
- PROPOSED FULLY PERFORATED SURFACE WATER PIPE
- RODDING EYE
- PROPOSED RAINGARDEN
- PROPOSED PERMEABLE PAVING
- PROPOSED SuDS DETENTION BASIN
- PROPOSED BELOW GROUND GEO-CELLULAR ATTENUATION
- PROPOSED CHECKED DAM
- PROPOSED NON-RETURN VALVE
- EXISTING MANHOLE
- EXISTING COMBINED WATER PIPELINE

NOTES:

1. DRAWING BASED ON THE FOLLOWING INFORMATION:
   1.1. TOPOGRAPHICAL SURVEY 'J342-001 REV A' BY LANDFORM SURVEYS DATED 11.09.23
   1.2. UTILITIES SURVEY 'J342u-002' BY LANDFORM SURVEYS DATED 25.08.23
   1.3. MASTERPLAN '2321-XSA-00-ZZ-DR-A-2200' BY XSITE ARCHITECTURE DATED 31.08.23
2. DRAINAGE DESIGNED TO NO FLOODING IN THE 1 IN 100 YEAR + 45% CC STORM EVENT. REFER TO THE HYDRAULIC CALCULATIONS FOR DETAIL.
3. ALL NEW DRAINAGE SHALL BE CONSTRUCTED IN ACCORDANCE WITH BUILDING REGULATIONS APPROVED DOCUMENT H AND BS EN 752.
4. INVERT LEVELS OF THE EXISTING DRAINAGE AT OUTFALL LOCATIONS ARE SUBJECT TO CONFIRMATION BY CCTV DRAINAGE SURVEY.



LOCATION KEY PLAN

| DATE | REV | DESCRIPTION | DRAWN | CHKD |
|---|---|---|---|---|
| 15.09.23 | P01 | ISSUED FOR PLANNING APPROVAL | RS | OD |

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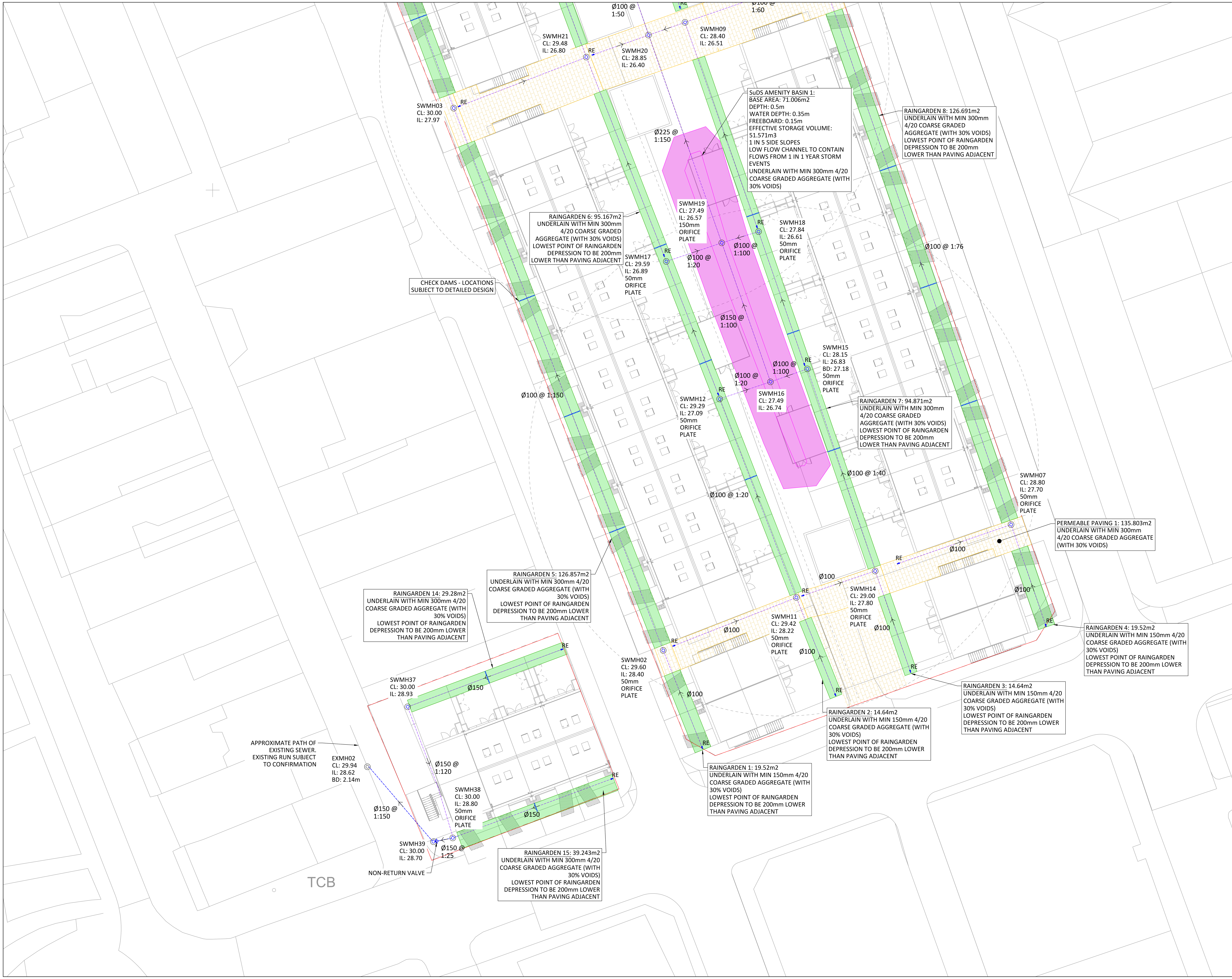
PROJECT
NILE & VILLIERS

TITLE
DRAWING LAYOUT
SHEET 1

| DRAWING STATUS | STATUS CODE |
|---|---|
| FOR PLANNING | - |

| CE PROJECT No. | SCALE @ A1 | DATE CREATED | DRAWN | CHECKED |
|---|---|---|---|---|
| 2920 | 1:200 | SEP 23 | RS | OD |

| DRAWING No. | REV |
|---|---|
| 2920-CIV-XX-XX-D-C-30001 | P01 |




STANDARD NOTES

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL RELEVANT ARCHITECT'S AND ENGINEER'S DRAWINGS AND THE SPECIFICATIONS.
2. THIS DRAWING SHOULD NOT BE SCALED.
3. ALL DIMENSIONS ARE TO BE VERIFIED BY THE CONTRACTOR ON SITE.
4. ALL DISCREPANCIES SHOULD BE REPORTED TO C.A./E.A. PRIOR TO THE COMMENCEMENT OF WORKS.



KEY:

- REDLINE BOUNDARY
- PROPOSED SURFACE WATER DRAINAGE
- PROPOSED SURFACE WATER MANHOLE
- PROPOSED SURFACE WATER INSPECTION CHAMBER
- PROPOSED FULLY PERFORATED SURFACE WATER PIPE
- RODDING EYE
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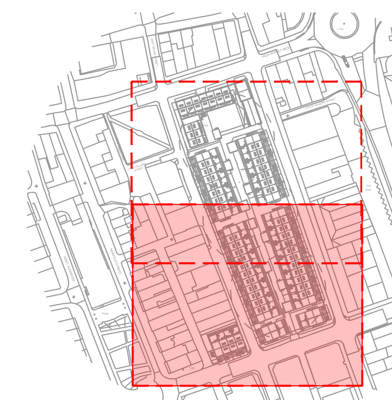
- PROPOSED PERMEABLE PAVING
- PROPOSED SuDS DETENTION BASIN
- PROPOSED BELOW GROUND GEO-CELLULAR ATTENUATION
- PROPOSED CHECKED DAM
- PROPOSED NON-RETURN VALVE
- EXISTING MANHOLE
- EXISTING COMBINED WATER PIPELINE

NOTES:

1. DRAWING BASED ON THE FOLLOWING INFORMATION:
   1.1. TOPOGRAPHICAL SURVEY 'J342-001 REV A' BY LANDFORM SURVEYS DATED 11.09.23
   1.2. UTILITIES SURVEY 'J342u-002' BY LANDFORM SURVEYS DATED 25.08.23
   1.3. MASTERPLAN '2321-XSA-00-ZZ-DR-A-2200' BY XSITE ARCHITECTURE DATED 31.08.23
2. DRAINAGE DESIGNED TO NO FLOODING IN THE 1 IN 100 YEAR + 45% CC STORM EVENT. REFER TO THE HYDRAULIC CALCULATIONS FOR DETAIL.
3. ALL NEW DRAINAGE SHALL BE CONSTRUCTED IN ACCORDANCE WITH BUILDING REGULATIONS APPROVED DOCUMENT H AND BS EN 752.
4. INVERT LEVELS OF THE EXISTING DRAINAGE AT OUTFALL LOCATIONS ARE SUBJECT TO CONFIRMATION BY CCTV DRAINAGE SURVEY.



LOCATION KEY PLAN

| DATE | REV | DESCRIPTION | DRAWN | CHKD |
|---|---|---|---|---|
| 18.09.23 | P01 | ISSUED FOR PLANNING APPROVAL | KL | OD |

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LEEDS 1 Saw Mill Street, Water Lane, Leeds, LS11 5WE. Tel: 0113 2025 130
GLASGOW 35 Virginia Street, Glasgow, G1 1TN. Tel: 0141 370 1829
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PROJECT
NILE & VILLIERS

TITLE
DRAINAGE LAYOUT
SHEET 2

| DRAWING STATUS | | | | STATUS CODE |
|---|---|---|---|---|
| FOR PLANNING | | | | - |
| CE PROJECT No. | SCALE @ A1 | DATE CREATED | DRAWN | CHECKED |
| 2920 | 1:200 | SEP 23 | KL | OD |
| DRAWING No. | | | | REV |
| 2920-CIV-XX-XX-D-C-30002 | | | | P01 |

## Appendix H: Greenfield Runoff Rate Calculations

hr wallingford

# Greenfield runoff rate estimation for sites

www.uksuds.com | Greenfield runoff tool

| | |
|---|---|
| Calculated by: | Kieran Lyons |
| Site name: | Nile and Villiers |
| Site location: | Sunderland |

This is an estimation of the greenfield runoff rates that are used to meet normal best practice criteria in line with Environment Agency guidance "Rainfall runoff management for developments", SC030219 (2013) , the SuDS Manual C753 (Ciria, 2015) and the non-statutory standards for SuDS (Defra, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

## Site Details

| | |
|---|---|
| Latitude: | 54.90704° N |
| Longitude: | 1.37681° W |
| Reference: | 687659238 |
| Date: | Sep 08 2023 11:40 |

## Runoff estimation approach

FEH Statistical

## Site characteristics

| | |
|---|---|
| Total site area (ha): | 0.81 |

## Methodology

| | |
|---|---|
| $Q_{MED}$ estimation method: | Calculate from BFI and SAAR |
| BFI and SPR method: | Calculate from dominant HOST |
| HOST class: | 24 |
| BFI / BFIHOST: | 0.333 |
| $Q_{MED}$ (l/s): | 2.57 |
| $Q_{BAR}$ / $Q_{MED}$ factor: | 1.06 |

## Hydrological characteristics

| | Default | Edited |
|---|---|---|
| SAAR (mm): | 619 | 619 |
| Hydrological region: | 3 | 3 |
| Growth curve factor 1 year: | 0.86 | 0.86 |
| Growth curve factor 30 years: | 1.75 | 1.75 |
| Growth curve factor 100 years: | 2.08 | 2.08 |
| Growth curve factor 200 years: | 2.37 | 2.37 |

## Notes

### (1) Is $Q_{BAR}$ < 2.0 l/s/ha?

When $Q_{BAR}$ is < 2.0 l/s/ha then limiting discharge rates are set at 2.0 l/s/ha.

### (2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consent for discharge is usually set at 5.0 l/s if blockage from vegetation and other materials is possible. Lower consent flow rates may be set where the blockage risk is addressed by using appropriate drainage elements.

### (3) Is SPR/SPRHOST ≤ 0.3?

Where groundwater levels are low enough the use of soakaways to avoid discharge offsite would normally be preferred for disposal of surface water runoff.

## Greenfield runoff rates

| | Default | Edited |
|---|---|---|
| $Q_{BAR}$ (l/s): | 2.74 | 2.74 |
| 1 in 1 year (l/s): | 2.35 | 2.35 |
| 1 in 30 years (l/s): | 4.79 | 4.79 |
| 1 in 100 year (l/s): | 5.69 | 5.69 |
| 1 in 200 years (l/s): | 6.48 | 6.48 |

## Appendix I: Proposed Drainage Calculations (Causeway Flow)

## Design Settings

| | | | |
|---|---|---|---|
| Rainfall Methodology | FSR | Maximum Time of Concentration (mins) | 30.00 |
| Return Period (years) | 2 | Maximum Rainfall (mm/hr) | 50.0 |
| Additional Flow (%) | 0 | Minimum Velocity (m/s) | 1.00 |
| FSR Region | England and Wales | Connection Type | Level Soffits |
| M5-60 (mm) | 17.000 | Minimum Backdrop Height (m) | 0.200 |
| Ratio-R | 0.300 | Preferred Cover Depth (m) | 1.200 |
| CV | 0.750 | Include Intermediate Ground | ✓ |
| Time of Entry (mins) | 4.00 | Enforce best practice design rules | x |

## Nodes

| | Name | Area (ha) | T of E (mins) | Cover Level (m) | Node Type | Manhole Type | Diameter (mm) | Easting (m) | Northing (m) | Depth (m) | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ✓ | 1 | 0.009 | 4.00 | 29.200 | Junction | | | 440059.037 | 557037.402 | 0.700 | |
| ✓ | 2 | 0.001 | 4.00 | 29.600 | Manhole | Adoptable | 300 | 440054.026 | 557048.908 | 1.200 | |
| ✓ | 3 | 0.051 | 4.00 | 30.000 | Junction | | | 440028.807 | 557112.489 | 2.080 | |
| ✓ | 4 | 0.035 | 4.00 | 29.300 | Junction | | | 440011.975 | 557157.169 | 1.854 | |
| ✓ | 5 | 0.034 | 4.00 | 28.610 | Junction | | | 440027.954 | 557162.458 | 1.830 | |
| ✓ | 6 | 0.009 | 4.00 | 28.630 | Junction | | | 440098.493 | 557051.623 | 0.730 | |
| ✓ | 7 | 0.006 | 4.00 | 28.800 | Junction | | | 440094.433 | 557063.421 | 1.100 | |
| ✓ | 8 | 0.060 | 4.00 | 28.000 | Junction | | | 440072.130 | 557128.153 | 1.200 | |
| ✓ | 9 | 0.031 | 4.00 | 28.400 | Junction | | | 440057.981 | 557123.273 | 1.890 | |
| ✓ | 10 | 0.008 | 4.00 | 28.940 | Junction | | | 440073.712 | 557043.441 | 0.700 | |
| ✓ | 11 | 0.005 | 4.00 | 29.420 | Junction | | | 440069.151 | 557054.837 | 1.200 | |
| ✓ | 12 | 0.016 | 4.00 | 29.290 | Junction | | | 440060.113 | 557078.223 | 2.200 | |
| ✓ | 13 | 0.016 | 4.00 | 28.370 | Junction | | | 440082.541 | 557046.213 | 0.470 | |
| ✓ | 14 | 0.003 | 4.00 | 29.000 | Junction | | | 440078.920 | 557057.950 | 1.200 | |
| ✓ | 15 | 0.022 | 4.00 | 28.150 | Junction | | | 440070.446 | 557081.765 | 1.320 | |
| ✓ | 16 | 0.045 | 4.00 | 27.490 | Manhole | Adoptable | 1200 | 440066.106 | 557080.240 | 0.750 | |
| ✓ | 17 | 0.011 | 4.00 | 29.590 | Junction | | | 440053.835 | 557094.425 | 2.700 | |
| ✓ | 18 | 0.011 | 4.00 | 27.840 | Junction | | | 440064.697 | 557097.940 | 1.230 | |
| ✓ | 19 | | | 27.490 | Manhole | Adoptable | 1200 | 440060.363 | 557096.614 | 0.920 | |
| ✓ | 20 | 0.008 | 4.00 | 28.850 | Manhole | Adoptable | 1200 | 440051.746 | 557121.096 | 2.450 | |
| ✓ | 21 | 0.023 | 4.00 | 29.480 | Junction | | | 440044.417 | 557118.503 | 2.680 | |

## Nodes

| | Name | Area (ha) | T of E (mins) | Cover Level (m) | Node Type | Manhole Type | Diameter (mm) | Easting (m) | Northing (m) | Depth (m) | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ✓ | 22 | 0.012 | 4.00 | 29.440 | Junction | | | 440037.790 | 557136.225 | 3.200 | |
| ✓ | 23 | 0.011 | 4.00 | 27.240 | Junction | | | 440050.095 | 557140.265 | 1.160 | |
| ✓ | 24 | 0.038 | 4.00 | 27.050 | Manhole | Adoptable | 1200 | 440045.657 | 557138.790 | 2.210 | |
| ✓ | 25 | 0.009 | 4.00 | 28.990 | Junction | | | 440032.623 | 557150.059 | 2.740 | |
| ✓ | 26 | 0.010 | 4.00 | 26.940 | Junction | | | 440045.368 | 557153.969 | 0.980 | |
| ✓ | 27 | | | 26.790 | Junction | | | 440039.692 | 557152.219 | 2.050 | |
| ✓ | 28 | 0.005 | 4.00 | 28.150 | Manhole | Adoptable | 1200 | 440035.628 | 557157.269 | 3.450 | |
| ✓ | 29 | | | 28.080 | Manhole | Adoptable | 1200 | 440033.286 | 557164.228 | 3.430 | |
| ✓ | 30 | 0.006 | 4.00 | 28.080 | Manhole | Adoptable | 1200 | 440035.064 | 557164.818 | 3.450 | Auto-design is off |
| ✓ | 31 | 0.024 | 4.00 | 29.000 | Junction | | | 440017.961 | 557178.942 | 2.260 | |
| ✓ | 32 | 0.032 | 4.00 | 27.780 | Junction | | | 440025.706 | 557180.313 | 1.420 | |
| ✓ | 33 | 0.029 | 4.00 | 27.000 | Junction | | | 440035.956 | 557183.466 | 0.900 | |
| ✓ | 34 | 0.027 | 4.00 | 27.550 | Junction | | | 440039.558 | 557172.707 | 1.560 | |
| ✓ | 35 | | | 27.900 | Junction | | | 440033.429 | 557170.080 | 1.970 | |
| ✓ | 30_OUT | | | 28.110 | Manhole | Adoptable | 1350 | 440034.534 | 557166.390 | 3.500 | Auto-design is off |
| ✓ | 36_OUT | | | 28.110 | Manhole | Adoptable | 1200 | 440039.358 | 557168.014 | 3.516 | |
| ✓ | 37 | 0.020 | 4.00 | 30.000 | Junction | | | 440023.377 | 557041.956 | 1.070 | |
| ✓ | 38 | 0.018 | 4.00 | 30.000 | Junction | | | 440028.690 | 557026.512 | 1.200 | |
| ✓ | 39 | | | 30.000 | Manhole | Adoptable | 1200 | 440026.209 | 557025.975 | 1.300 | |
| ✓ | 39_OUT | | | 29.940 | Manhole | Adoptable | 1200 | 440018.639 | 557034.892 | 1.320 | |
| ✓ | 40 | 0.020 | 4.00 | 27.500 | Junction | | | 440040.766 | 557167.650 | 1.700 | |
| ✓ | 41 | 0.035 | 4.00 | 26.750 | Junction | | | 440057.450 | 557170.671 | 1.130 | |
| ✓ | 42 | | | 26.800 | Manhole | Adoptable | 1200 | 440056.676 | 557172.839 | 1.250 | |
| ✓ | 42_OUT | | | 26.800 | Manhole | Adoptable | 1200 | 440056.363 | 557173.793 | 1.260 | |

## Simulation Settings

| | | | | | |
|---|---|---|---|---|---|
| Rainfall Methodology | FSR | Summer CV | 0.750 | Drain Down Time (mins) | 1440 |
| FSR Region | England and Wales | Winter CV | 0.840 | Additional Storage ($m^3$/ha) | 0.0 |
| M5-60 (mm) | 17.000 | Analysis Speed | Normal | Check Discharge Rate(s) | x |
| Ratio-R | 0.300 | Skip Steady State | x | Check Discharge Volume | x |

**Storm Durations**

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

| Return Period (years) | Climate Change (CC %) | Additional Area (A %) | Additional Flow (Q %) | Return Period (years) | Climate Change (CC %) | Additional Area (A %) | Additional Flow (Q %) |
|---|---|---|---|---|---|---|---|
| 1 | 0 | 10 | 0 | 100 | 0 | 10 | 0 |
| 30 | 0 | 10 | 0 | 100 | 45 | 10 | 0 |

**Node 42 Online Orifice Control**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Flap Valve | ✓ | Replaces Downstream Link | ✓ | Design Depth (m) | 1.250 | Diameter (m) | 0.050 |
| Downstream Link | 13.001 | Invert Level (m) | 25.550 | Design Flow (l/s) | 1.5 | Discharge Coefficient | 0.600 |

**Node 35 Online Orifice Control**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Flap Valve | x | Replaces Downstream Link | ✓ | Design Depth (m) | 1.970 | Diameter (m) | 0.050 |
| Downstream Link | 11.004 | Invert Level (m) | 25.930 | Design Flow (l/s) | 1.5 | Discharge Coefficient | 0.600 |

**Node 30 Online Orifice Control**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Flap Valve | x | Replaces Downstream Link | ✓ | Design Depth (m) | 3.450 | Diameter (m) | 0.050 |
| Downstream Link | 1.006 | Invert Level (m) | 24.630 | Design Flow (l/s) | 1.5 | Discharge Coefficient | 0.600 |

**Node 22 Online Orifice Control**

| | | | | | |
|---|---|---|---|---|---|
| Flap Valve | x | Replaces Downstream Link | ✓ | Diameter (m) | 0.050 |
| Downstream Link | 7.001 | Invert Level (m) | 26.440 | Discharge Coefficient | 0.600 |

**Node 23 Online Orifice Control**

| | | | | | |
|---|---|---|---|---|---|
| Flap Valve | x | Replaces Downstream Link | ✓ | Diameter (m) | 0.050 |
| Downstream Link | 8.000 | Invert Level (m) | 26.080 | Discharge Coefficient | 0.600 |

**Node 25 Online Orifice Control**

| | | | | | |
|---|---|---|---|---|---|
| Flap Valve | x | Replaces Downstream Link | ✓ | Diameter (m) | 0.050 |
| Downstream Link | 9.000 | Invert Level (m) | 26.250 | Discharge Coefficient | 0.600 |

**Node 26 Online Orifice Control**

| | | | | | |
|---|---|---|---|---|---|
| Flap Valve | x | Replaces Downstream Link | ✓ | Diameter (m) | 0.050 |
| Downstream Link | 10.000 | Invert Level (m) | 25.960 | Discharge Coefficient | 0.600 |

**Node 19 Online Orifice Control**

| | | | | | |
|---|---|---|---|---|---|
| Flap Valve | x | Replaces Downstream Link | ✓ | Diameter (m) | 0.150 |
| Downstream Link | 3.004 | Invert Level (m) | 26.570 | Discharge Coefficient | 0.600 |

**Node 21 Online Orifice Control**

| | | | | | |
|---|---|---|---|---|---|
| Flap Valve | x | Replaces Downstream Link | ✓ | Diameter (m) | 0.050 |
| Downstream Link | 7.000 | Invert Level (m) | 26.800 | Discharge Coefficient | 0.600 |

**Node 2 Online Orifice Control**

| | | | | | |
|---|---|---|---|---|---|
| Flap Valve | x | Replaces Downstream Link | ✓ | Diameter (m) | 0.050 |
| Downstream Link | 1.001 | Invert Level (m) | 28.400 | Discharge Coefficient | 0.600 |

**Node 11 Online Orifice Control**

| | | | | | |
|---|---|---|---|---|---|
| Flap Valve | x | Replaces Downstream Link | ✓ | Diameter (m) | 0.050 |
| Downstream Link | 3.001 | Invert Level (m) | 28.220 | Discharge Coefficient | 0.600 |

**Node 14 Online Orifice Control**

| | | | | | |
|---|---|---|---|---|---|
| Flap Valve | x | Replaces Downstream Link | ✓ | Diameter (m) | 0.075 |
| Downstream Link | 4.001 | Invert Level (m) | 27.800 | Discharge Coefficient | 0.600 |

**Node 7 Online Orifice Control**

| | | | | | |
|---|---|---|---|---|---|
| Flap Valve | x | Replaces Downstream Link | ✓ | Diameter (m) | 0.050 |
| Downstream Link | 2.001 | Invert Level (m) | 27.700 | Discharge Coefficient | 0.600 |

## Node 8 Online Orifice Control

| | | | | | |
|---|---|---|---|---|---|
| Flap Valve | x | Replaces Downstream Link | ✓ | Diameter (m) | 0.075 |
| Downstream Link | 2.002 | Invert Level (m) | 26.800 | Discharge Coefficient | 0.600 |

## Node 17 Online Orifice Control

| | | | | | |
|---|---|---|---|---|---|
| Flap Valve | x | Replaces Downstream Link | ✓ | Diameter (m) | 0.050 |
| Downstream Link | 5.000 | Invert Level (m) | 26.890 | Discharge Coefficient | 0.600 |

## Node 18 Online Orifice Control

| | | | | | |
|---|---|---|---|---|---|
| Flap Valve | x | Replaces Downstream Link | ✓ | Diameter (m) | 0.050 |
| Downstream Link | 6.000 | Invert Level (m) | 26.610 | Discharge Coefficient | 0.600 |

## Node 12 Online Orifice Control

| | | | | | |
|---|---|---|---|---|---|
| Flap Valve | x | Replaces Downstream Link | ✓ | Diameter (m) | 0.050 |
| Downstream Link | 3.002 | Invert Level (m) | 27.090 | Discharge Coefficient | 0.600 |

## Node 15 Online Orifice Control

| | | | | | |
|---|---|---|---|---|---|
| Flap Valve | x | Replaces Downstream Link | ✓ | Diameter (m) | 0.075 |
| Downstream Link | 4.002 | Invert Level (m) | 26.830 | Discharge Coefficient | 0.600 |

## Node 39 Online Orifice Control

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Flap Valve | x | Replaces Downstream Link | ✓ | Design Depth (m) | 1.110 | Diameter (m) | 0.050 |
| Downstream Link | 12.002 | Invert Level (m) | 28.700 | Design Flow (l/s) | 1.5 | Discharge Coefficient | 0.600 |

## Node 19 Soakaway Storage Structure

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Porosity | 0.30 | Pit Width (m) | 1.817 | Inf Depth (m) | |
| Side Inf Coefficient (m/hr) | 0.00000 | Invert Level (m) | 26.570 | Pit Length (m) | 39.070 | Number Required | 1 |
| Safety Factor | 2.0 | Time to half empty (mins) | 21 | Depth (m) | 0.300 | | |

## Node 27 Soakaway Storage Structure

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Porosity | 0.95 | Pit Width (m) | 8.602 | Inf Depth (m) | |
| Side Inf Coefficient (m/hr) | 0.00000 | Invert Level (m) | 24.740 | Pit Length (m) | 26.603 | Number Required | 1 |
| Safety Factor | 2.0 | Time to half empty (mins) | 735 | Depth (m) | 1.200 | | |

## Node 1 Soakaway Storage Structure

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Porosity | 0.30 | Pit Width (m) | 2.000 | Inf Depth (m) | |
| Side Inf Coefficient (m/hr) | 0.00000 | Invert Level (m) | 28.500 | Pit Length (m) | 9.760 | Number Required | 1 |
| Safety Factor | 2.0 | Time to half empty (mins) | 9 | Depth (m) | 0.150 | | |

## Node 10 Soakaway Storage Structure

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Porosity | 0.30 | Pit Width (m) | 2.000 | Inf Depth (m) | |
| Side Inf Coefficient (m/hr) | 0.00000 | Invert Level (m) | 28.240 | Pit Length (m) | 7.320 | Number Required | 1 |
| Safety Factor | 2.0 | Time to half empty (mins) | 23 | Depth (m) | 0.150 | | |

## Node 13 Soakaway Storage Structure

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Porosity | 0.30 | Pit Width (m) | 2.000 | Inf Depth (m) | |
| Side Inf Coefficient (m/hr) | 0.00000 | Invert Level (m) | 27.900 | Pit Length (m) | 7.320 | Number Required | 1 |
| Safety Factor | 2.0 | Time to half empty (mins) | 10 | Depth (m) | 0.150 | | |

## Node 6 Soakaway Storage Structure

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Porosity | 0.30 | Pit Width (m) | 2.000 | Inf Depth (m) | |
| Side Inf Coefficient (m/hr) | 0.00000 | Invert Level (m) | 27.930 | Pit Length (m) | 9.762 | Number Required | 1 |
| Safety Factor | 2.0 | Time to half empty (mins) | 0 | Depth (m) | 0.150 | | |

## Node 7 Carpark Storage Structure

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Porosity | 0.30 | Width (m) | 17.348 | Depth (m) | 0.300 |
| Side Inf Coefficient (m/hr) | 0.00000 | Invert Level (m) | 27.700 | Length (m) | 3.547 | Inf Depth (m) | |
| Safety Factor | 2.0 | Time to half empty (mins) | 11 | Slope (1:X) | 84.0 | | |

## Node 14 Carpark Storage Structure

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Porosity | 0.30 | Width (m) | 10.030 | Depth (m) | 0.300 |
| Side Inf Coefficient (m/hr) | 0.00000 | Invert Level (m) | 27.800 | Length (m) | 3.489 | Inf Depth (m) | |
| Safety Factor | 2.0 | Time to half empty (mins) | 8 | Slope (1:X) | 28.0 | | |

## Node 11 Carpark Storage Structure

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Porosity | 0.30 | Width (m) | 14.600 | Depth (m) | 0.300 |
| Side Inf Coefficient (m/hr) | 0.00000 | Invert Level (m) | 28.220 | Length (m) | 3.334 | Inf Depth (m) | |
| Safety Factor | 2.0 | Time to half empty (mins) | 0 | Slope (1:X) | 88.0 | | |

## Node 2 Carpark Storage Structure

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Porosity | 0.30 | Width (m) | 2.009 | Depth (m) | 0.300 |
| Side Inf Coefficient (m/hr) | 0.00000 | Invert Level (m) | 28.400 | Length (m) | 3.430 | Inf Depth (m) | |
| Safety Factor | 2.0 | Time to half empty (mins) | 10 | Slope (1:X) | 100.0 | | |

## Node 21 Carpark Storage Structure

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Porosity | 0.30 | Width (m) | 14.329 | Depth (m) | 0.300 |
| Side Inf Coefficient (m/hr) | 0.00000 | Invert Level (m) | 26.800 | Length (m) | 5.975 | Inf Depth (m) | |
| Safety Factor | 2.0 | Time to half empty (mins) | 24 | Slope (1:X) | 32.0 | | |

## Node 9 Carpark Storage Structure

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Porosity | 0.30 | Width (m) | 14.445 | Depth (m) | 0.300 |
| Side Inf Coefficient (m/hr) | 0.00000 | Invert Level (m) | 26.510 | Length (m) | 5.855 | Inf Depth (m) | |
| Safety Factor | 2.0 | Time to half empty (mins) | 0 | Slope (1:X) | 11.0 | | |

## Node 8 Carpark Storage Structure

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Porosity | 0.30 | Width (m) | 15.728 | Depth (m) | 0.300 |
| Side Inf Coefficient (m/hr) | 0.00000 | Invert Level (m) | 26.800 | Length (m) | 6.073 | Inf Depth (m) | |
| Safety Factor | 2.0 | Time to half empty (mins) | 48 | Slope (1:X) | 41.0 | | |

**Node 3 Soakaway Storage Structure**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Porosity | 0.30 | Pit Width (m) | 2.000 | Inf Depth (m) | |
| Side Inf Coefficient (m/hr) | 0.00000 | Invert Level (m) | 27.920 | Pit Length (m) | 63.429 | Number Required | 1 |
| Safety Factor | 2.0 | Time to half empty (mins) | 9 | Depth (m) | 0.300 | | |

**Node 3 Carpark Storage Structure**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Porosity | 0.30 | Width (m) | 1.660 | Depth (m) | 0.300 |
| Side Inf Coefficient (m/hr) | 0.00000 | Invert Level (m) | 27.920 | Length (m) | 6.151 | Inf Depth (m) | |
| Safety Factor | 2.0 | Time to half empty (mins) | 8 | Slope (1:X) | 150.0 | | |

**Node 40 Carpark Storage Structure**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Porosity | 0.30 | Width (m) | 18.245 | Depth (m) | 0.300 |
| Side Inf Coefficient (m/hr) | 0.00000 | Invert Level (m) | 25.800 | Length (m) | 5.602 | Inf Depth (m) | |
| Safety Factor | 2.0 | Time to half empty (mins) | 48 | Slope (1:X) | 22.0 | | |

**Node 5 Soakaway Storage Structure**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Porosity | 0.30 | Pit Width (m) | 1.500 | Inf Depth (m) | |
| Side Inf Coefficient (m/hr) | 0.00000 | Invert Level (m) | 26.780 | Pit Length (m) | 8.746 | Number Required | 1 |
| Safety Factor | 2.0 | Time to half empty (mins) | 0 | Depth (m) | 0.300 | | |

**Node 33 Soakaway Storage Structure**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Porosity | 0.30 | Pit Width (m) | 1.250 | Inf Depth (m) | |
| Side Inf Coefficient (m/hr) | 0.00000 | Invert Level (m) | 26.100 | Pit Length (m) | 28.036 | Number Required | 1 |
| Safety Factor | 2.0 | Time to half empty (mins) | 236 | Depth (m) | 0.300 | | |

**Node 34 Soakaway Storage Structure**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Porosity | 0.30 | Pit Width (m) | 10.910 | Inf Depth (m) | |
| Side Inf Coefficient (m/hr) | 0.00000 | Invert Level (m) | 25.990 | Pit Length (m) | 9.030 | Number Required | 1 |
| Safety Factor | 2.0 | Time to half empty (mins) | 272 | Depth (m) | 0.300 | | |

## Node 8 Soakaway Storage Structure

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Porosity | 0.30 | Pit Width (m) | 2.000 | Inf Depth (m) | |
| Side Inf Coefficient (m/hr) | 0.00000 | Invert Level (m) | 26.800 | Pit Length (m) | 63.350 | Number Required | 1 |
| Safety Factor | 2.0 | Time to half empty (mins) | 59 | Depth (m) | 0.300 | | |

## Node 22 Soakaway Storage Structure

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Porosity | 0.30 | Pit Width (m) | 1.500 | Inf Depth (m) | |
| Side Inf Coefficient (m/hr) | 0.00000 | Invert Level (m) | 26.240 | Pit Length (m) | 27.845 | Number Required | 1 |
| Safety Factor | 2.0 | Time to half empty (mins) | | Depth (m) | 0.300 | | |

## Node 25 Soakaway Storage Structure

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Porosity | 0.30 | Pit Width (m) | 1.500 | Inf Depth (m) | |
| Side Inf Coefficient (m/hr) | 0.00000 | Invert Level (m) | 26.250 | Pit Length (m) | 14.726 | Number Required | 1 |
| Safety Factor | 2.0 | Time to half empty (mins) | 240 | Depth (m) | 0.300 | | |

## Node 23 Soakaway Storage Structure

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Porosity | 0.30 | Pit Width (m) | 1.500 | Inf Depth (m) | |
| Side Inf Coefficient (m/hr) | 0.00000 | Invert Level (m) | 26.080 | Pit Length (m) | 17.604 | Number Required | 1 |
| Safety Factor | 2.0 | Time to half empty (mins) | 270 | Depth (m) | 0.300 | | |

## Node 26 Soakaway Storage Structure

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Porosity | 0.30 | Pit Width (m) | 1.500 | Inf Depth (m) | |
| Side Inf Coefficient (m/hr) | 0.00000 | Invert Level (m) | 25.960 | Pit Length (m) | 14.549 | Number Required | 1 |
| Safety Factor | 2.0 | Time to half empty (mins) | 270 | Depth (m) | 0.300 | | |

## Node 4 Soakaway Storage Structure

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Porosity | 0.30 | Pit Width (m) | 2.000 | Inf Depth (m) | |
| Side Inf Coefficient (m/hr) | 0.00000 | Invert Level (m) | 27.446 | Pit Length (m) | 43.920 | Number Required | 1 |
| Safety Factor | 2.0 | Time to half empty (mins) | 0 | Depth (m) | 0.300 | | |

## Node 5 Carpark Storage Structure

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Porosity | 0.30 | Width (m) | 15.030 | Depth (m) | 0.300 |
| Side Inf Coefficient (m/hr) | 0.00000 | Invert Level (m) | 26.780 | Length (m) | 5.202 | Inf Depth (m) | |
| Safety Factor | 2.0 | Time to half empty (mins) | 0 | Slope (1:X) | 20.0 | | |

## Node 31 Carpark Storage Structure

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Porosity | 0.30 | Width (m) | 12.276 | Depth (m) | 0.300 |
| Side Inf Coefficient (m/hr) | 0.00000 | Invert Level (m) | 26.740 | Length (m) | 3.886 | Inf Depth (m) | |
| Safety Factor | 2.0 | Time to half empty (mins) | 0 | Slope (1:X) | 100.0 | | |

## Node 32 Carpark Storage Structure

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Porosity | 0.30 | Width (m) | 27.500 | Depth (m) | 0.300 |
| Side Inf Coefficient (m/hr) | 0.00000 | Invert Level (m) | 26.360 | Length (m) | 13.480 | Inf Depth (m) | |
| Safety Factor | 2.0 | Time to half empty (mins) | 120 | Slope (1:X) | 100.0 | | |

## Node 35 Carpark Storage Structure

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Porosity | 0.30 | Width (m) | 4.545 | Depth (m) | 0.300 |
| Side Inf Coefficient (m/hr) | 0.00000 | Invert Level (m) | 25.930 | Length (m) | 34.139 | Inf Depth (m) | |
| Safety Factor | 2.0 | Time to half empty (mins) | 0 | Slope (1:X) | 23.0 | | |

## Node 41 Soakaway Storage Structure

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Porosity | 0.30 | Pit Width (m) | 2.000 | Inf Depth (m) | |
| Side Inf Coefficient (m/hr) | 0.00000 | Invert Level (m) | 25.620 | Pit Length (m) | 44.194 | Number Required | 1 |
| Safety Factor | 2.0 | Time to half empty (mins) | 112 | Depth (m) | 0.300 | | |

## Node 37 Soakaway Storage Structure

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Porosity | 0.30 | Pit Width (m) | 19.520 | Inf Depth (m) | |
| Side Inf Coefficient (m/hr) | 0.00000 | Invert Level (m) | 28.930 | Pit Length (m) | 1.500 | Number Required | 1 |
| Safety Factor | 2.0 | Time to half empty (mins) | 33 | Depth (m) | 0.300 | | |

## Node 38 Soakaway Storage Structure

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Porosity | 0.30 | Pit Width (m) | 2.000 | Inf Depth (m) | |
| Side Inf Coefficient (m/hr) | 0.00000 | Invert Level (m) | 28.800 | Pit Length (m) | 19.622 | Number Required | 1 |
| Safety Factor | 2.0 | Time to half empty (mins) | 53 | Depth (m) | 0.300 | | |

## Node 27 Depth/Area Storage Structure

| | | | | | |
|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Safety Factor | 2.0 | Invert Level (m) | 26.440 |
| Side Inf Coefficient (m/hr) | 0.00000 | Porosity | 1.00 | Time to half empty (mins) | 180 |

| Depth (m) | Area (m²) | Inf Area (m²) | Depth (m) | Area (m²) | Inf Area (m²) | Depth (m) | Area (m²) | Inf Area (m²) |
|---|---|---|---|---|---|---|---|---|
| 0.000 | 76.2 | 0.0 | 0.350 | 178.4 | 0.0 | 0.351 | 0.0 | 0.0 |

## Node 19 Depth/Area Storage Structure

| | | | | | |
|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Safety Factor | 2.0 | Invert Level (m) | 27.140 |
| Side Inf Coefficient (m/hr) | 0.00000 | Porosity | 1.00 | Time to half empty (mins) | 0 |

| Depth (m) | Area (m²) | Inf Area (m²) | Depth (m) | Area (m²) | Inf Area (m²) | Depth (m) | Area (m²) | Inf Area (m²) |
|---|---|---|---|---|---|---|---|---|
| 0.000 | 71.0 | 0.0 | 0.175 | 144.2 | 0.0 | 0.350 | 222.7 | 0.0 |

## Node 40 Soakaway Storage Structure

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Porosity | 0.30 | Pit Width (m) | 1.500 | Inf Depth (m) | |
| Side Inf Coefficient (m/hr) | 0.00000 | Invert Level (m) | 25.800 | Pit Length (m) | 11.920 | Number Required | 1 |
| Safety Factor | 2.0 | Time to half empty (mins) | 58 | Depth (m) | 0.300 | | |

## Node 5 Soakaway Storage Structure

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Porosity | 0.30 | Pit Width (m) | 1.500 | Inf Depth (m) | |
| Side Inf Coefficient (m/hr) | 0.00000 | Invert Level (m) | 26.780 | Pit Length (m) | 11.258 | Number Required | 1 |
| Safety Factor | 2.0 | Time to half empty (mins) | 0 | Depth (m) | 0.300 | | |

**Node 21 Soakaway Storage Structure**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Porosity | 0.30 | Pit Width (m) | 1.500 | Inf Depth (m) | |
| Side Inf Coefficient (m/hr) | 0.00000 | Invert Level (m) | 26.800 | Pit Length (m) | 20.980 | Number Required | 1 |
| Safety Factor | 2.0 | Time to half empty (mins) | 37 | Depth (m) | 0.300 | | |

**Node 9 Soakaway Storage Structure**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Porosity | 0.30 | Pit Width (m) | 1.500 | Inf Depth (m) | |
| Side Inf Coefficient (m/hr) | 0.00000 | Invert Level (m) | 26.510 | Pit Length (m) | 21.117 | Number Required | 1 |
| Safety Factor | 2.0 | Time to half empty (mins) | 15 | Depth (m) | 0.300 | | |

**Node 17 Soakaway Storage Structure**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Porosity | 0.30 | Pit Width (m) | 1.500 | Inf Depth (m) | |
| Side Inf Coefficient (m/hr) | 0.00000 | Invert Level (m) | 26.890 | Pit Length (m) | 17.450 | Number Required | 1 |
| Safety Factor | 2.0 | Time to half empty (mins) | 10 | Depth (m) | 0.300 | | |

**Node 18 Soakaway Storage Structure**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Porosity | 0.30 | Pit Width (m) | 1.500 | Inf Depth (m) | |
| Side Inf Coefficient (m/hr) | 0.00000 | Invert Level (m) | 26.610 | Pit Length (m) | 17.085 | Number Required | 1 |
| Safety Factor | 2.0 | Time to half empty (mins) | 24 | Depth (m) | 0.300 | | |

**Node 12 Soakaway Storage Structure**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Porosity | 0.30 | Pit Width (m) | 1.500 | Inf Depth (m) | |
| Side Inf Coefficient (m/hr) | 0.00000 | Invert Level (m) | 27.090 | Pit Length (m) | 24.945 | Number Required | 1 |
| Safety Factor | 2.0 | Time to half empty (mins) | 49 | Depth (m) | 0.300 | | |

**Node 15 Soakaway Storage Structure**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Porosity | 0.30 | Pit Width (m) | 1.500 | Inf Depth (m) | |
| Side Inf Coefficient (m/hr) | 0.00000 | Invert Level (m) | 26.830 | Pit Length (m) | 24.998 | Number Required | 1 |
| Safety Factor | 2.0 | Time to half empty (mins) | 26 | Depth (m) | 0.300 | | |

## Rainfall

| Event | Peak Intensity (mm/hr) | Average Intensity (mm/hr) |
|---|---|---|
| 1 year +10% A 15 minute summer | 84.280 | 23.848 |
| 1 year +10% A 15 minute winter | 59.144 | 23.848 |
| 1 year +10% A 30 minute summer | 57.102 | 16.158 |
| 1 year +10% A 30 minute winter | 40.072 | 16.158 |
| 1 year +10% A 60 minute summer | 40.398 | 10.676 |
| 1 year +10% A 60 minute winter | 26.839 | 10.676 |
| 1 year +10% A 120 minute summer | 26.432 | 6.985 |
| 1 year +10% A 120 minute winter | 17.561 | 6.985 |
| 1 year +10% A 180 minute summer | 21.115 | 5.434 |
| 1 year +10% A 180 minute winter | 13.725 | 5.434 |
| 1 year +10% A 240 minute summer | 17.197 | 4.545 |
| 1 year +10% A 240 minute winter | 11.425 | 4.545 |
| 1 year +10% A 360 minute summer | 13.694 | 3.524 |
| 1 year +10% A 360 minute winter | 8.901 | 3.524 |
| 1 year +10% A 480 minute summer | 11.066 | 2.925 |
| 1 year +10% A 480 minute winter | 7.352 | 2.925 |
| 1 year +10% A 600 minute summer | 9.254 | 2.531 |
| 1 year +10% A 600 minute winter | 6.323 | 2.531 |
| 1 year +10% A 720 minute summer | 8.394 | 2.250 |
| 1 year +10% A 720 minute winter | 5.641 | 2.250 |
| 1 year +10% A 960 minute summer | 7.097 | 1.869 |
| 1 year +10% A 960 minute winter | 4.701 | 1.869 |
| 1 year +10% A 1440 minute summer | 5.374 | 1.440 |
| 1 year +10% A 1440 minute winter | 3.611 | 1.440 |
| 30 year +10% A 15 minute summer | 205.071 | 58.028 |
| 30 year +10% A 15 minute winter | 143.910 | 58.028 |
| 30 year +10% A 30 minute summer | 140.191 | 39.669 |
| 30 year +10% A 30 minute winter | 98.380 | 39.669 |
| 30 year +10% A 60 minute summer | 98.615 | 26.061 |
| 30 year +10% A 60 minute winter | 65.517 | 26.061 |
| 30 year +10% A 120 minute summer | 63.038 | 16.659 |
| 30 year +10% A 120 minute winter | 41.881 | 16.659 |

| Event | Peak Intensity (mm/hr) | Average Intensity (mm/hr) |
|---|---|---|
| 30 year +10% A 180 minute summer | 49.285 | 12.683 |
| 30 year +10% A 180 minute winter | 32.037 | 12.683 |
| 30 year +10% A 240 minute summer | 39.344 | 10.398 |
| 30 year +10% A 240 minute winter | 26.139 | 10.398 |
| 30 year +10% A 360 minute summer | 30.343 | 7.808 |
| 30 year +10% A 360 minute winter | 19.724 | 7.808 |
| 30 year +10% A 480 minute summer | 24.111 | 6.372 |
| 30 year +10% A 480 minute winter | 16.019 | 6.372 |
| 30 year +10% A 600 minute summer | 19.882 | 5.438 |
| 30 year +10% A 600 minute winter | 13.585 | 5.438 |
| 30 year +10% A 720 minute summer | 17.819 | 4.776 |
| 30 year +10% A 720 minute winter | 11.975 | 4.776 |
| 30 year +10% A 960 minute summer | 14.763 | 3.887 |
| 30 year +10% A 960 minute winter | 9.779 | 3.887 |
| 30 year +10% A 1440 minute summer | 10.836 | 2.904 |
| 30 year +10% A 1440 minute winter | 7.282 | 2.904 |
| 100 year +10% A 15 minute summer | 263.467 | 74.552 |
| 100 year +10% A 15 minute winter | 184.889 | 74.552 |
| 100 year +10% A 30 minute summer | 182.215 | 51.561 |
| 100 year +10% A 30 minute winter | 127.870 | 51.561 |
| 100 year +10% A 60 minute summer | 129.253 | 34.158 |
| 100 year +10% A 60 minute winter | 85.873 | 34.158 |
| 100 year +10% A 120 minute summer | 82.920 | 21.913 |
| 100 year +10% A 120 minute winter | 55.090 | 21.913 |
| 100 year +10% A 180 minute summer | 64.733 | 16.658 |
| 100 year +10% A 180 minute winter | 42.078 | 16.658 |
| 100 year +10% A 240 minute summer | 51.503 | 13.611 |
| 100 year +10% A 240 minute winter | 34.217 | 13.611 |
| 100 year +10% A 360 minute summer | 39.411 | 10.142 |
| 100 year +10% A 360 minute winter | 25.618 | 10.142 |
| 100 year +10% A 480 minute summer | 31.156 | 8.234 |
| 100 year +10% A 480 minute winter | 20.700 | 8.234 |

## Rainfall

| Event | Peak Intensity (mm/hr) | Average Intensity (mm/hr) |
|---|---|---|
| 100 year +10% A 600 minute summer | 25.583 | 6.998 |
| 100 year +10% A 600 minute winter | 17.480 | 6.998 |
| 100 year +10% A 720 minute summer | 22.845 | 6.123 |
| 100 year +10% A 720 minute winter | 15.353 | 6.123 |
| 100 year +10% A 960 minute summer | 18.812 | 4.954 |
| 100 year +10% A 960 minute winter | 12.461 | 4.954 |
| 100 year +10% A 1440 minute summer | 13.679 | 3.666 |
| 100 year +10% A 1440 minute winter | 9.193 | 3.666 |
| 100 year +45% CC +10% A 15 minute summer | 382.027 | 108.100 |
| 100 year +45% CC +10% A 15 minute winter | 268.089 | 108.100 |
| 100 year +45% CC +10% A 30 minute summer | 264.212 | 74.763 |
| 100 year +45% CC +10% A 30 minute winter | 185.412 | 74.763 |
| 100 year +45% CC +10% A 60 minute summer | 187.417 | 49.529 |
| 100 year +45% CC +10% A 60 minute winter | 124.515 | 49.529 |
| 100 year +45% CC +10% A 120 minute summer | 120.234 | 31.774 |
| 100 year +45% CC +10% A 120 minute winter | 79.881 | 31.774 |

| Event | Peak Intensity (mm/hr) | Average Intensity (mm/hr) |
|---|---|---|
| 100 year +45% CC +10% A 180 minute summer | 93.863 | 24.154 |
| 100 year +45% CC +10% A 180 minute winter | 61.013 | 24.154 |
| 100 year +45% CC +10% A 240 minute summer | 74.679 | 19.735 |
| 100 year +45% CC +10% A 240 minute winter | 49.615 | 19.735 |
| 100 year +45% CC +10% A 360 minute summer | 57.145 | 14.705 |
| 100 year +45% CC +10% A 360 minute winter | 37.146 | 14.705 |
| 100 year +45% CC +10% A 480 minute summer | 45.177 | 11.939 |
| 100 year +45% CC +10% A 480 minute winter | 30.014 | 11.939 |
| 100 year +45% CC +10% A 600 minute summer | 37.095 | 10.146 |
| 100 year +45% CC +10% A 600 minute winter | 25.346 | 10.146 |
| 100 year +45% CC +10% A 720 minute summer | 33.125 | 8.878 |
| 100 year +45% CC +10% A 720 minute winter | 22.262 | 8.878 |
| 100 year +45% CC +10% A 960 minute summer | 27.277 | 7.183 |
| 100 year +45% CC +10% A 960 minute winter | 18.069 | 7.183 |
| 100 year +45% CC +10% A 1440 minute summer | 19.835 | 5.316 |
| 100 year +45% CC +10% A 1440 minute winter | 13.330 | 5.316 |

**Results for 1 year +10% A Critical Storm Duration. Lowest mass balance: 99.12%**

| Node Event | US Node | Peak (mins) | Level (m) | Depth (m) | Inflow (l/s) | Node Vol (m³) | Flood (m³) | Status |
|---|---|---|---|---|---|---|---|---|
| 15 minute winter | 1 | 11 | 28.528 | 0.028 | 1.1 | 0.1656 | 0.0000 | OK |
| 15 minute winter | 2 | 13 | 28.453 | 0.053 | 1.0 | 0.0796 | 0.0000 | OK |
| 60 minute winter | 3 | 39 | 27.979 | 0.059 | 4.1 | 2.3624 | 0.0000 | OK |
| 30 minute winter | 4 | 21 | 27.483 | 0.037 | 5.2 | 0.9837 | 0.0000 | OK |
| 30 minute summer | 5 | 19 | 26.822 | 0.042 | 7.7 | 0.4614 | 0.0000 | OK |
| 15 minute winter | 6 | 10 | 27.926 | 0.026 | 1.1 | 0.0000 | 0.0000 | OK |
| 30 minute winter | 7 | 22 | 27.748 | 0.048 | 1.5 | 0.5004 | 0.0000 | OK |
| 60 minute winter | 8 | 43 | 26.879 | 0.079 | 4.7 | 3.6344 | 0.0000 | OK |
| 15 minute winter | 9 | 11 | 26.556 | 0.046 | 4.9 | 0.4718 | 0.0000 | OK |
| 15 minute winter | 10 | 11 | 28.279 | 0.039 | 1.0 | 0.1717 | 0.0000 | OK |
| 30 minute winter | 11 | 24 | 28.263 | 0.043 | 1.2 | 0.3486 | 0.0000 | OK |
| 60 minute winter | 12 | 41 | 27.163 | 0.073 | 1.6 | 0.8232 | 0.0000 | OK |
| 15 minute winter | 13 | 10 | 27.940 | 0.040 | 2.0 | 0.1765 | 0.0000 | OK |
| 15 minute winter | 14 | 12 | 27.865 | 0.065 | 2.3 | 0.1829 | 0.0000 | OK |
| 30 minute winter | 15 | 22 | 26.921 | 0.091 | 3.6 | 1.0184 | 0.0000 | OK |

| Link Event (Outflow) | 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 | 0.9 | 0.385 | 0.175 | 0.0367 | |
| 15 minute winter | 2 | Orifice | 3 | 0.9 | | | | |
| 60 minute winter | 3 | 1.002 | 4 | 2.8 | 0.500 | 0.306 | 0.2679 | |
| 30 minute winter | 4 | 1.003 | 5 | 4.8 | 1.338 | 0.135 | 0.0622 | |
| 30 minute summer | 5 | 1.004 | 29 | 7.5 | 1.902 | 0.158 | 0.0220 | |
| 15 minute winter | 6 | 2.000 | 7 | 1.1 | 0.583 | 0.143 | 0.0289 | |
| 30 minute winter | 7 | Orifice | 8 | 0.8 | | | | |
| 60 minute winter | 8 | Orifice | 9 | 2.4 | | | | |
| 15 minute winter | 9 | 2.003 | 20 | 4.6 | 0.878 | 0.200 | 0.0356 | |
| 15 minute winter | 10 | 3.000 | 11 | 0.8 | 0.301 | 0.325 | 0.0327 | |
| 30 minute winter | 11 | Orifice | 12 | 0.7 | | | | |
| 60 minute winter | 12 | Orifice | 16 | 1.1 | | | | |
| 15 minute winter | 13 | 4.000 | 14 | 1.9 | 0.502 | 0.341 | 0.0501 | |
| 15 minute winter | 14 | Orifice | 15 | 1.8 | | | | |
| 30 minute winter | 15 | Orifice | 16 | 2.7 | | | | |

**Results for 1 year +10% A Critical Storm Duration. Lowest mass balance: 99.12%**

| Node Event | US Node | Peak (mins) | Level (m) | Depth (m) | Inflow (l/s) | Node Vol (m³) | Flood (m³) | Status |
|---|---|---|---|---|---|---|---|---|
| 15 minute winter | 16 | 10 | 26.816 | 0.076 | 8.1 | 0.0854 | 0.0000 | OK |
| 30 minute winter | 17 | 21 | 26.936 | 0.046 | 1.1 | 0.3621 | 0.0000 | OK |
| 30 minute winter | 18 | 23 | 26.673 | 0.063 | 1.1 | 0.4837 | 0.0000 | OK |
| 30 minute winter | 19 | 23 | 26.668 | 0.098 | 8.5 | 2.2089 | 0.0000 | OK |
| 30 minute winter | 20 | 21 | 26.462 | 0.062 | 11.3 | 0.0701 | 0.0000 | OK |
| 30 minute winter | 21 | 23 | 26.865 | 0.065 | 2.3 | 0.9016 | 0.0000 | OK |
| 240 minute winter | 22 | 148 | 26.490 | 0.250 | 1.0 | 3.1283 | 0.0000 | OK |
| 30 minute winter | 23 | 21 | 26.126 | 0.046 | 1.1 | 0.3642 | 0.0000 | OK |
| 480 minute winter | 24 | 368 | 24.970 | 0.130 | 6.0 | 0.1474 | 0.0000 | OK |
| 30 minute winter | 25 | 21 | 26.292 | 0.042 | 0.9 | 0.2806 | 0.0000 | OK |
| 15 minute winter | 26 | 12 | 26.006 | 0.046 | 1.3 | 0.3000 | 0.0000 | OK |
| 480 minute winter | 27 | 368 | 24.970 | 0.230 | 6.5 | 50.0633 | 0.0000 | OK |
| 480 minute winter | 28 | 360 | 24.970 | 0.270 | 5.1 | 0.3056 | 0.0000 | OK |
| 480 minute winter | 29 | 376 | 24.973 | 0.323 | 4.7 | 0.3656 | 0.0000 | SURCHARGED |
| 480 minute winter | 30 | 360 | 24.971 | 0.341 | 6.9 | 0.3856 | 0.0000 | SURCHARGED |

| Link Event (Outflow) | US Node | Link | DS Node | Outflow (l/s) | Velocity (m/s) | Flow/Cap | Link Vol (m³) | Discharge Vol (m³) |
|---|---|---|---|---|---|---|---|---|
| 15 minute winter | 16 | 3.003 | 19 | 8.0 | 1.160 | 0.457 | 0.1522 | |
| 30 minute winter | 17 | Orifice | 19 | 0.7 | | | | |
| 60 minute winter | 18 | Orifice | 19 | 0.5 | | | | |
| 30 minute winter | 19 | Orifice | 20 | 6.8 | | | | |
| 30 minute winter | 20 | 2.004 | 24 | 11.3 | 1.302 | 0.156 | 0.1619 | |
| 30 minute winter | 21 | Orifice | 22 | 1.0 | | | | |
| 240 minute winter | 22 | Orifice | 24 | 0.8 | | | | |
| 30 minute winter | 23 | Orifice | 24 | 0.7 | | | | |
| 30 minute winter | 24 | 2.005 | 27 | 14.7 | 1.678 | 0.161 | 0.1951 | |
| 30 minute winter | 25 | Orifice | 27 | 0.6 | | | | |
| 15 minute winter | 26 | Orifice | 27 | 0.7 | | | | |
| 30 minute summer | 27 | 2.006 | 28 | -6.9 | -0.718 | -0.079 | 0.1536 | |
| 30 minute summer | 28 | 2.007 | 29 | -6.2 | 0.352 | -0.067 | 0.2709 | |
| 360 minute winter | 29 | 1.005 | 30 | 16.9 | 0.280 | 0.147 | 0.1319 | |
| 480 minute winter | 30 | Orifice | 30_OUT | 2.9 | | | | |

**Results for 1 year +10% A Critical Storm Duration. Lowest mass balance: 99.12%**

| Node Event | US Node | Peak (mins) | Level (m) | Depth (m) | Inflow (l/s) | Node Vol (m³) | Flood (m³) | Status |
|---|---|---|---|---|---|---|---|---|
| 15 minute winter | 31 | 10 | 26.771 | 0.031 | 3.0 | 0.1789 | 0.0000 | OK |
| 15 minute winter | 32 | 12 | 26.410 | 0.050 | 6.8 | 1.0343 | 0.0000 | OK |
| 15 minute winter | 33 | 11 | 26.168 | 0.068 | 7.6 | 0.7136 | 0.0000 | OK |
| 60 minute winter | 34 | 47 | 26.165 | 0.175 | 7.6 | 5.1601 | 0.0000 | SURCHARGED |
| 60 minute winter | 35 | 47 | 26.163 | 0.233 | 6.1 | 0.1940 | 0.0000 | SURCHARGED |
| 180 minute winter | 30_OUT | 132 | 24.669 | 0.059 | 4.8 | 0.0845 | 0.0000 | OK |
| 180 minute winter | 36_OUT | 132 | 24.646 | 0.052 | 4.8 | 0.0000 | 0.0000 | OK |
| 15 minute winter | 37 | 11 | 28.968 | 0.038 | 2.5 | 0.3343 | 0.0000 | OK |
| 30 minute summer | 38 | 22 | 28.860 | 0.060 | 5.7 | 0.7030 | 0.0000 | OK |
| 30 minute winter | 39 | 23 | 28.902 | 0.202 | 8.7 | 0.2282 | 0.0000 | SURCHARGED |
| 15 minute summer | 39_OUT | 1 | 28.620 | 0.000 | 2.1 | 0.0000 | 0.0000 | OK |
| 15 minute winter | 40 | 11 | 25.839 | 0.039 | 2.5 | 0.3055 | 0.0000 | OK |
| 30 minute winter | 41 | 25 | 25.695 | 0.075 | 3.8 | 2.0014 | 0.0000 | OK |
| 30 minute winter | 42 | 25 | 25.695 | 0.145 | 2.2 | 0.1639 | 0.0000 | OK |
| 15 minute summer | 42_OUT | 1 | 25.540 | 0.000 | 1.7 | 0.0000 | 0.0000 | OK |

| Link Event (Outflow) | US Node | Link | DS Node | Outflow (l/s) | Velocity (m/s) | Flow/Cap | Link Vol (m³) | Discharge Vol (m³) |
|---|---|---|---|---|---|---|---|---|
| 15 minute winter | 31 | 11.000 | 32 | 2.8 | 1.024 | 0.208 | 0.0230 | |
| 15 minute winter | 32 | 11.001 | 33 | 4.7 | 1.000 | 0.499 | 0.0512 | |
| 15 minute winter | 33 | 11.002 | 34 | 7.3 | 1.106 | 0.420 | 0.1156 | |
| 60 minute winter | 34 | 11.003 | 35 | 6.1 | 0.451 | 0.360 | 0.1174 | |
| 60 minute winter | 35 | Orifice | 30_OUT | 2.4 | | | | |
| 180 minute winter | 30_OUT | 1.007 | 36_OUT | 4.8 | 0.541 | 0.078 | 0.0456 | 86.8 |
| 15 minute winter | 37 | 12.000 | 38 | 2.2 | 0.626 | 0.142 | 0.0722 | |
| 15 minute winter | 38 | 12.001 | 39 | 9.4 | 0.677 | 0.265 | 0.0303 | |
| 30 minute winter | 39 | Orifice | 39_OUT | 2.2 | | | | 2.9 |
| 15 minute winter | 40 | 13.000 | 42 | 2.1 | 0.615 | 0.324 | 0.0771 | |
| 30 minute winter | 41 | 14.000 | 42 | 1.4 | 0.496 | 0.251 | 0.0161 | |
| 30 minute winter | 42 | Orifice | 42_OUT | 1.8 | | | | 4.1 |

**Results for 30 year +10% A Critical Storm Duration. Lowest mass balance: 99.12%**

| Node Event | US Node | Peak (mins) | Level (m) | Depth (m) | Inflow (l/s) | Node Vol (m³) | Flood (m³) | Status |
|---|---|---|---|---|---|---|---|---|
| 15 minute winter | 1 | 12 | 28.550 | 0.050 | 2.8 | 0.2934 | 0.0000 | OK |
| 15 minute winter | 2 | 12 | 28.545 | 0.145 | 2.8 | 0.2743 | 0.0000 | SURCHARGED |
| 30 minute winter | 3 | 22 | 28.034 | 0.114 | 13.9 | 4.6394 | 0.0000 | OK |
| 30 minute winter | 4 | 20 | 27.512 | 0.066 | 14.7 | 1.7451 | 0.0000 | OK |
| 15 minute winter | 5 | 11 | 26.858 | 0.078 | 22.7 | 0.9860 | 0.0000 | OK |
| 15 minute winter | 6 | 10 | 27.941 | 0.041 | 2.8 | 0.0651 | 0.0000 | OK |
| 30 minute winter | 7 | 24 | 27.798 | 0.098 | 3.6 | 1.4145 | 0.0000 | OK |
| 60 minute winter | 8 | 46 | 26.972 | 0.172 | 11.1 | 9.3283 | 0.0000 | SURCHARGED |
| 15 minute winter | 9 | 11 | 26.590 | 0.080 | 12.3 | 0.8540 | 0.0000 | OK |
| 15 minute winter | 10 | 11 | 28.309 | 0.069 | 2.5 | 0.3026 | 0.0000 | OK |
| 30 minute winter | 11 | 23 | 28.305 | 0.085 | 2.9 | 0.9628 | 0.0000 | OK |
| 60 minute winter | 12 | 44 | 27.290 | 0.200 | 3.7 | 2.2399 | 0.0000 | SURCHARGED |
| 15 minute winter | 13 | 10 | 27.971 | 0.071 | 4.9 | 0.3115 | 0.0000 | OK |
| 15 minute winter | 14 | 13 | 27.931 | 0.131 | 5.6 | 0.7223 | 0.0000 | SURCHARGED |
| 30 minute winter | 15 | 23 | 27.069 | 0.239 | 8.4 | 2.6850 | 0.0000 | SURCHARGED |

| Link Event (Outflow) | 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 | 2.5 | 0.449 | 0.464 | 0.0737 | |
| 15 minute winter | 2 | Orifice | 3 | 1.8 | | | | |
| 30 minute winter | 3 | 1.002 | 4 | 8.2 | 0.665 | 0.892 | 0.5834 | |
| 30 minute winter | 4 | 1.003 | 5 | 14.3 | 1.762 | 0.403 | 0.1378 | |
| 15 minute winter | 5 | 1.004 | 29 | 22.1 | 2.502 | 0.469 | 0.0497 | |
| 15 minute winter | 6 | 2.000 | 7 | 2.7 | 0.673 | 0.346 | 0.0594 | |
| 30 minute winter | 7 | Orifice | 8 | 1.4 | | | | |
| 60 minute winter | 8 | Orifice | 9 | 4.3 | | | | |
| 15 minute winter | 9 | 2.003 | 20 | 11.5 | 1.081 | 0.501 | 0.0722 | |
| 15 minute winter | 10 | 3.000 | 11 | 2.1 | 0.419 | 0.894 | 0.0702 | |
| 30 minute winter | 11 | Orifice | 12 | 1.3 | | | | |
| 60 minute winter | 12 | Orifice | 16 | 2.2 | | | | |
| 15 minute winter | 13 | 4.000 | 14 | 4.7 | 0.642 | 0.855 | 0.0845 | |
| 15 minute winter | 14 | Orifice | 15 | 3.6 | | | | |
| 30 minute winter | 15 | Orifice | 16 | 5.3 | | | | |

**Results for 30 year +10% A Critical Storm Duration. Lowest mass balance: 99.12%**

| Node Event | US Node | Peak (mins) | Level (m) | Depth (m) | Inflow (l/s) | Node Vol (m³) | Flood (m³) | Status |
|---|---|---|---|---|---|---|---|---|
| 15 minute winter | 16 | 11 | 26.905 | 0.165 | 18.6 | 0.1866 | 0.0000 | SURCHARGED |
| 30 minute winter | 17 | 22 | 27.000 | 0.110 | 2.7 | 0.8652 | 0.0000 | SURCHARGED |
| 30 minute winter | 18 | 24 | 26.781 | 0.171 | 2.7 | 1.3136 | 0.0000 | SURCHARGED |
| 30 minute winter | 19 | 22 | 26.753 | 0.183 | 18.2 | 4.1137 | 0.0000 | OK |
| 30 minute summer | 20 | 19 | 26.499 | 0.099 | 26.4 | 0.1125 | 0.0000 | OK |
| 60 minute winter | 21 | 42 | 26.936 | 0.136 | 3.8 | 2.5527 | 0.0000 | SURCHARGED |
| 120 minute winter | 22 | 72 | 26.702 | 0.462 | 2.8 | 3.7653 | 0.0000 | SURCHARGED |
| 30 minute winter | 23 | 22 | 26.190 | 0.110 | 2.7 | 0.8690 | 0.0000 | SURCHARGED |
| 480 minute winter | 24 | 392 | 25.394 | 0.554 | 13.2 | 0.6266 | 0.0000 | SURCHARGED |
| 15 minute winter | 25 | 13 | 26.346 | 0.096 | 2.8 | 0.6331 | 0.0000 | OK |
| 15 minute winter | 26 | 13 | 26.067 | 0.107 | 3.1 | 0.6991 | 0.0000 | SURCHARGED |
| 480 minute winter | 27 | 392 | 25.394 | 0.654 | 15.8 | 142.1569 | 0.0000 | SURCHARGED |
| 480 minute winter | 28 | 392 | 25.394 | 0.694 | 10.2 | 0.7847 | 0.0000 | SURCHARGED |
| 480 minute winter | 29 | 392 | 25.394 | 0.744 | 18.6 | 0.8411 | 0.0000 | SURCHARGED |
| 480 minute winter | 30 | 392 | 25.394 | 0.764 | 15.3 | 0.8636 | 0.0000 | SURCHARGED |

| Link Event (Outflow) | US Node | Link | DS Node | Outflow (l/s) | Velocity (m/s) | Flow/Cap | Link Vol (m³) | Discharge Vol (m³) |
|---|---|---|---|---|---|---|---|---|
| 15 minute winter | 16 | 3.003 | 19 | 17.9 | 1.259 | 1.020 | 0.3053 | |
| 30 minute winter | 17 | Orifice | 19 | 1.5 | | | | |
| 60 minute winter | 18 | Orifice | 19 | 1.1 | | | | |
| 30 minute winter | 19 | Orifice | 20 | 15.5 | | | | |
| 30 minute summer | 20 | 2.004 | 24 | 26.5 | 1.628 | 0.366 | 0.3043 | |
| 60 minute winter | 21 | Orifice | 22 | 1.7 | | | | |
| 120 minute winter | 22 | Orifice | 24 | 2.5 | | | | |
| 30 minute winter | 23 | Orifice | 24 | 1.5 | | | | |
| 15 minute winter | 24 | 2.005 | 27 | 37.4 | 2.256 | 0.409 | 0.5968 | |
| 15 minute winter | 25 | Orifice | 27 | 1.4 | | | | |
| 15 minute winter | 26 | Orifice | 27 | 1.5 | | | | |
| 15 minute winter | 27 | 2.006 | 28 | -22.3 | -1.114 | -0.256 | 0.3886 | |
| 15 minute winter | 28 | 2.007 | 29 | -21.2 | -0.471 | -0.231 | 0.4963 | |
| 120 minute summer | 29 | 1.005 | 30 | -100.4 | -1.428 | -0.874 | 0.1319 | |
| 480 minute winter | 30 | Orifice | 30_OUT | 4.4 | | | | |

**Results for 30 year +10% A Critical Storm Duration. Lowest mass balance: 99.12%**

| Node Event | US Node | Peak (mins) | Level (m) | Depth (m) | Inflow (l/s) | Node Vol ($m^3$) | Flood ($m^3$) | Status |
|---|---|---|---|---|---|---|---|---|
| 15 minute winter | 31 | 10 | 26.791 | 0.051 | 7.4 | 0.4494 | 0.0000 | OK |
| 120 minute winter | 32 | 90 | 26.478 | 0.118 | 6.6 | 5.7271 | 0.0000 | SURCHARGED |
| 120 minute winter | 33 | 84 | 26.471 | 0.371 | 8.6 | 3.1595 | 0.0000 | SURCHARGED |
| 120 minute winter | 34 | 82 | 26.469 | 0.479 | 9.4 | 8.8813 | 0.0000 | SURCHARGED |
| 120 minute winter | 35 | 82 | 26.465 | 0.535 | 7.0 | 0.9524 | 0.0000 | SURCHARGED |
| 240 minute winter | 30_OUT | 188 | 24.685 | 0.075 | 7.7 | 0.1070 | 0.0000 | OK |
| 240 minute winter | 36_OUT | 188 | 24.660 | 0.066 | 7.7 | 0.0000 | 0.0000 | OK |
| 30 minute winter | 37 | 24 | 29.020 | 0.090 | 4.8 | 0.7937 | 0.0000 | OK |
| 30 minute winter | 38 | 25 | 29.019 | 0.219 | 11.4 | 2.5800 | 0.0000 | SURCHARGED |
| 30 minute winter | 39 | 25 | 29.018 | 0.318 | 5.1 | 0.3599 | 0.0000 | SURCHARGED |
| 15 minute summer | 39_OUT | 1 | 28.620 | 0.000 | 2.6 | 0.0000 | 0.0000 | OK |
| 15 minute winter | 40 | 11 | 25.867 | 0.067 | 6.1 | 0.6333 | 0.0000 | OK |
| 60 minute winter | 41 | 46 | 25.862 | 0.242 | 6.3 | 6.4267 | 0.0000 | SURCHARGED |
| 60 minute winter | 42 | 46 | 25.860 | 0.310 | 3.2 | 0.3502 | 0.0000 | SURCHARGED |
| 15 minute summer | 42_OUT | 1 | 25.540 | 0.000 | 2.4 | 0.0000 | 0.0000 | OK |

| Link Event (Outflow) | US Node | Link | DS Node | Outflow (l/s) | Velocity (m/s) | Flow/Cap | Link Vol ($m^3$) | Discharge Vol ($m^3$) |
|---|---|---|---|---|---|---|---|---|
| 15 minute winter | 31 | 11.000 | 32 | 6.8 | 1.346 | 0.510 | 0.0419 | |
| 15 minute winter | 32 | 11.001 | 33 | 9.3 | 1.202 | 0.985 | 0.0798 | |
| 15 minute summer | 33 | 11.002 | 34 | 15.6 | 1.199 | 0.894 | 0.1997 | |
| 60 minute winter | 34 | 11.003 | 35 | 8.0 | 0.456 | 0.477 | 0.1174 | |
| 120 minute winter | 35 | Orifice | 30_OUT | 3.7 | | | | |
| 240 minute winter | 30_OUT | 1.007 | 36_OUT | 7.7 | 0.613 | 0.124 | 0.0638 | 227.9 |
| 15 minute winter | 37 | 12.000 | 38 | 5.7 | 0.712 | 0.358 | 0.2140 | |
| 120 minute summer | 38 | 12.001 | 39 | 9.8 | 0.678 | 0.276 | 0.0447 | |
| 30 minute winter | 39 | Orifice | 39_OUT | 2.8 | | | | 7.0 |
| 15 minute winter | 40 | 13.000 | 42 | 5.1 | 0.696 | 0.771 | 0.1120 | |
| 15 minute summer | 41 | 14.000 | 42 | -2.4 | 0.502 | -0.420 | 0.0180 | |
| 60 minute winter | 42 | Orifice | 42_OUT | 2.8 | | | | 13.2 |

**Results for 100 year +10% A Critical Storm Duration. Lowest mass balance: 99.12%**

| Node Event | US Node | Peak (mins) | Level (m) | Depth (m) | Inflow (l/s) | Node Vol (m³) | Flood (m³) | Status |
|---|---|---|---|---|---|---|---|---|
| 15 minute winter | 1 | 13 | 28.574 | 0.074 | 3.6 | 0.4362 | 0.0000 | OK |
| 15 minute winter | 2 | 13 | 28.566 | 0.166 | 3.2 | 0.3204 | 0.0000 | SURCHARGED |
| 30 minute winter | 3 | 22 | 28.063 | 0.143 | 17.9 | 5.8227 | 0.0000 | OK |
| 30 minute summer | 4 | 19 | 27.524 | 0.078 | 20.2 | 2.0577 | 0.0000 | OK |
| 15 minute winter | 5 | 11 | 26.874 | 0.094 | 30.0 | 1.2581 | 0.0000 | OK |
| 15 minute winter | 6 | 10 | 27.947 | 0.047 | 3.6 | 0.1015 | 0.0000 | OK |
| 30 minute winter | 7 | 24 | 27.826 | 0.126 | 4.6 | 1.9398 | 0.0000 | SURCHARGED |
| 60 minute winter | 8 | 47 | 27.021 | 0.221 | 14.3 | 12.5975 | 0.0000 | SURCHARGED |
| 15 minute winter | 9 | 11 | 26.604 | 0.094 | 15.4 | 1.0191 | 0.0000 | OK |
| 30 minute winter | 10 | 23 | 28.329 | 0.089 | 2.5 | 0.3924 | 0.0000 | OK |
| 30 minute winter | 11 | 24 | 28.327 | 0.107 | 3.7 | 1.2829 | 0.0000 | SURCHARGED |
| 60 minute winter | 12 | 45 | 27.363 | 0.273 | 4.7 | 3.0687 | 0.0000 | SURCHARGED |
| 15 minute winter | 13 | 12 | 28.014 | 0.114 | 6.3 | 0.5017 | 0.0000 | SURCHARGED |
| 15 minute winter | 14 | 14 | 27.950 | 0.150 | 6.4 | 0.9297 | 0.0000 | SURCHARGED |
| 30 minute winter | 15 | 22 | 27.410 | 0.580 | 10.3 | 3.3803 | 0.0000 | SURCHARGED |

| Link Event (Outflow) | US Node | Link | DS Node | Outflow (l/s) | Velocity (m/s) | Flow/Cap | Link Vol (m³) | Discharge Vol (m³) |
|---|---|---|---|---|---|---|---|---|
| 15 minute summer | 1 | 1.000 | 2 | 3.2 | 0.475 | 0.588 | 0.0844 | |
| 15 minute winter | 2 | Orifice | 3 | 2.0 | | | | |
| 30 minute winter | 3 | 1.002 | 4 | 10.2 | 0.687 | 1.118 | 0.6896 | |
| 30 minute summer | 4 | 1.003 | 5 | 19.0 | 1.835 | 0.535 | 0.1751 | |
| 15 minute winter | 5 | 1.004 | 29 | 29.3 | 2.656 | 0.621 | 0.0619 | |
| 15 minute winter | 6 | 2.000 | 7 | 3.4 | 0.713 | 0.446 | 0.0685 | |
| 30 minute winter | 7 | Orifice | 8 | 1.7 | | | | |
| 60 minute winter | 8 | Orifice | 9 | 5.0 | | | | |
| 15 minute winter | 9 | 2.003 | 20 | 14.5 | 1.142 | 0.630 | 0.0846 | |
| 15 minute winter | 10 | 3.000 | 11 | 2.7 | 0.443 | 1.112 | 0.0880 | |
| 30 minute winter | 11 | Orifice | 12 | 1.5 | | | | |
| 60 minute winter | 12 | Orifice | 16 | 2.6 | | | | |
| 15 minute winter | 13 | 4.000 | 14 | 5.2 | 0.693 | 0.961 | 0.0961 | |
| 15 minute winter | 14 | Orifice | 15 | 3.9 | | | | |
| 30 minute winter | 15 | Orifice | 16 | 7.5 | | | | |

**Results for 100 year +10% A Critical Storm Duration. Lowest mass balance: 99.12%**

| Node Event | US Node | Peak (mins) | Level (m) | Depth (m) | Inflow (l/s) | Node Vol (m³) | Flood (m³) | Status |
|---|---|---|---|---|---|---|---|---|
| 30 minute winter | 16 | 21 | 27.017 | 0.277 | 19.2 | 0.3132 | 0.0000 | SURCHARGED |
| 30 minute winter | 17 | 22 | 27.039 | 0.149 | 3.5 | 1.1679 | 0.0000 | SURCHARGED |
| 30 minute winter | 18 | 24 | 26.836 | 0.226 | 3.5 | 1.7371 | 0.0000 | SURCHARGED |
| 30 minute winter | 19 | 23 | 26.800 | 0.230 | 21.2 | 5.1554 | 0.0000 | SURCHARGED |
| 30 minute summer | 20 | 19 | 26.512 | 0.111 | 31.9 | 0.1261 | 0.0000 | OK |
| 60 minute winter | 21 | 44 | 26.971 | 0.171 | 5.0 | 3.6439 | 0.0000 | SURCHARGED |
| 60 minute winter | 22 | 41 | 26.853 | 0.613 | 4.3 | 3.7653 | 0.0000 | SURCHARGED |
| 30 minute winter | 23 | 22 | 26.228 | 0.148 | 3.5 | 1.1723 | 0.0000 | SURCHARGED |
| 600 minute winter | 24 | 480 | 25.636 | 0.796 | 14.4 | 0.9000 | 0.0000 | SURCHARGED |
| 30 minute winter | 25 | 21 | 26.377 | 0.127 | 2.8 | 0.8440 | 0.0000 | SURCHARGED |
| 30 minute winter | 26 | 21 | 26.106 | 0.146 | 3.1 | 0.9577 | 0.0000 | SURCHARGED |
| 600 minute winter | 27 | 480 | 25.636 | 0.896 | 17.2 | 194.6905 | 0.0000 | SURCHARGED |
| 600 minute winter | 28 | 480 | 25.635 | 0.935 | 6.4 | 1.0580 | 0.0000 | SURCHARGED |
| 600 minute winter | 29 | 480 | 25.635 | 0.985 | 6.2 | 1.1144 | 0.0000 | SURCHARGED |
| 600 minute winter | 30 | 480 | 25.635 | 1.005 | 8.3 | 1.1368 | 0.0000 | SURCHARGED |

| Link Event (Outflow) | US Node | Link | DS Node | Outflow (l/s) | Velocity (m/s) | Flow/Cap | Link Vol (m³) | Discharge Vol (m³) |
|---|---|---|---|---|---|---|---|---|
| 15 minute winter | 16 | 3.003 | 19 | 20.6 | 1.280 | 1.171 | 0.3055 | |
| 30 minute winter | 17 | Orifice | 19 | 1.8 | | | | |
| 60 minute winter | 18 | Orifice | 19 | 1.3 | | | | |
| 30 minute winter | 19 | Orifice | 20 | 18.5 | | | | |
| 30 minute summer | 20 | 2.004 | 24 | 32.0 | 1.704 | 0.443 | 0.3515 | |
| 60 minute winter | 21 | Orifice | 22 | 2.0 | | | | |
| 60 minute winter | 22 | Orifice | 24 | 3.2 | | | | |
| 30 minute winter | 23 | Orifice | 24 | 1.8 | | | | |
| 15 minute winter | 24 | 2.005 | 27 | 46.4 | 2.336 | 0.507 | 0.8634 | |
| 30 minute winter | 25 | Orifice | 27 | 1.7 | | | | |
| 30 minute winter | 26 | Orifice | 27 | 1.8 | | | | |
| 15 minute winter | 27 | 2.006 | 28 | -30.0 | -1.225 | -0.345 | 0.4548 | |
| 15 minute winter | 28 | 2.007 | 29 | -28.6 | -0.557 | -0.312 | 0.5171 | |
| 60 minute winter | 29 | 1.005 | 30 | 41.7 | 0.594 | 0.363 | 0.1319 | |
| 600 minute winter | 30 | Orifice | 30_OUT | 5.1 | | | | |

**Results for 100 year +10% A Critical Storm Duration. Lowest mass balance: 99.12%**

| Node Event | US Node | Peak (mins) | Level (m) | Depth (m) | Inflow (l/s) | Node Vol (m³) | Flood (m³) | Status |
|---|---|---|---|---|---|---|---|---|
| 15 minute winter | 31 | 10 | 26.799 | 0.059 | 9.5 | 0.5732 | 0.0000 | OK |
| 120 minute winter | 32 | 92 | 26.548 | 0.188 | 11.0 | 13.4559 | 0.0000 | SURCHARGED |
| 60 minute winter | 33 | 38 | 26.559 | 0.459 | 13.5 | 3.1595 | 0.0000 | SURCHARGED |
| 60 minute winter | 34 | 38 | 26.559 | 0.569 | 15.2 | 8.8813 | 0.0000 | SURCHARGED |
| 60 minute winter | 35 | 38 | 26.555 | 0.625 | 9.7 | 1.2877 | 0.0000 | SURCHARGED |
| 240 minute winter | 30_OUT | 216 | 24.689 | 0.079 | 8.6 | 0.1135 | 0.0000 | OK |
| 240 minute winter | 36_OUT | 216 | 24.664 | 0.070 | 8.6 | 0.0000 | 0.0000 | OK |
| 60 minute winter | 37 | 44 | 29.094 | 0.164 | 4.3 | 1.4417 | 0.0000 | SURCHARGED |
| 60 minute winter | 38 | 44 | 29.093 | 0.293 | 7.7 | 3.4456 | 0.0000 | SURCHARGED |
| 60 minute winter | 39 | 44 | 29.091 | 0.391 | 9.5 | 0.4427 | 0.0000 | SURCHARGED |
| 15 minute summer | 39_OUT | 1 | 28.620 | 0.000 | 2.9 | 0.0000 | 0.0000 | OK |
| 60 minute winter | 40 | 47 | 25.942 | 0.142 | 4.3 | 1.9730 | 0.0000 | SURCHARGED |
| 60 minute winter | 41 | 42 | 25.948 | 0.328 | 8.2 | 7.9681 | 0.0000 | SURCHARGED |
| 60 minute winter | 42 | 45 | 25.936 | 0.386 | 3.8 | 0.4368 | 0.0000 | SURCHARGED |
| 15 minute summer | 42_OUT | 1 | 25.540 | 0.000 | 2.7 | 0.0000 | 0.0000 | OK |

| Link Event (Outflow) | US Node | Link | DS Node | Outflow (l/s) | Velocity (m/s) | Flow/Cap | Link Vol (m³) | Discharge Vol (m³) |
|---|---|---|---|---|---|---|---|---|
| 15 minute winter | 31 | 11.000 | 32 | 8.8 | 1.465 | 0.658 | 0.0489 | |
| 15 minute winter | 32 | 11.001 | 33 | 9.3 | 1.192 | 0.979 | 0.0839 | |
| 15 minute summer | 33 | 11.002 | 34 | 17.3 | 1.226 | 0.993 | 0.1997 | |
| 30 minute winter | 34 | 11.003 | 35 | 10.7 | 0.607 | 0.635 | 0.1174 | |
| 60 minute winter | 35 | Orifice | 30_OUT | 4.0 | | | | |
| 240 minute winter | 30_OUT | 1.007 | 36_OUT | 8.6 | 0.635 | 0.139 | 0.0693 | 300.1 |
| | | | | | | | | |
| 15 minute winter | 37 | 12.000 | 38 | 7.4 | 0.695 | 0.469 | 0.2717 | |
| 30 minute winter | 38 | 12.001 | 39 | 10.1 | 0.699 | 0.284 | 0.0447 | |
| 60 minute winter | 39 | Orifice | 39_OUT | 3.2 | | | | 12.0 |
| | | | | | | | | |
| 15 minute summer | 40 | 13.000 | 42 | 5.6 | 0.744 | 0.851 | 0.1239 | |
| 60 minute winter | 41 | 14.000 | 42 | 3.7 | 0.504 | 0.655 | 0.0180 | |
| 60 minute winter | 42 | Orifice | 42_OUT | 3.1 | | | | 17.4 |

**Results for 100 year +45% CC +10% A Critical Storm Duration. Lowest mass balance: 99.12%**

| Node Event | US Node | Peak (mins) | Level (m) | Depth (m) | Inflow (l/s) | Node Vol (m³) | Flood (m³) | Status |
|---|---|---|---|---|---|---|---|---|
| 30 minute winter | 1 | 22 | 28.644 | 0.144 | 4.1 | 0.8440 | 0.0000 | SURCHARGED |
| 30 minute winter | 2 | 22 | 28.626 | 0.226 | 2.8 | 0.4475 | 0.0000 | SURCHARGED |
| 30 minute winter | 3 | 23 | 28.131 | 0.211 | 25.3 | 8.6287 | 0.0000 | SURCHARGED |
| 15 minute winter | 4 | 11 | 27.545 | 0.099 | 29.8 | 2.6062 | 0.0000 | OK |
| 15 minute winter | 5 | 11 | 26.910 | 0.130 | 44.7 | 1.9409 | 0.0000 | OK |
| 15 minute winter | 6 | 10 | 27.959 | 0.059 | 5.2 | 0.1714 | 0.0000 | OK |
| 60 minute winter | 7 | 43 | 27.888 | 0.188 | 4.7 | 3.0656 | 0.0000 | SURCHARGED |
| 60 minute winter | 8 | 44 | 27.480 | 0.680 | 20.6 | 17.9162 | 0.0000 | SURCHARGED |
| 600 minute winter | 9 | 480 | 26.662 | 0.152 | 6.1 | 1.7628 | 0.0000 | SURCHARGED |
| 60 minute winter | 10 | 42 | 28.384 | 0.144 | 2.5 | 0.6346 | 0.0000 | SURCHARGED |
| 60 minute winter | 11 | 43 | 28.379 | 0.159 | 3.5 | 2.0502 | 0.0000 | SURCHARGED |
| 60 minute winter | 12 | 41 | 28.137 | 1.047 | 6.6 | 3.3731 | 0.0000 | SURCHARGED |
| 15 minute winter | 13 | 11 | 28.201 | 0.301 | 9.2 | 0.6610 | 0.0000 | FLOOD RISK |
| 30 minute winter | 14 | 23 | 28.077 | 0.277 | 7.7 | 2.2628 | 0.0000 | SURCHARGED |
| 30 minute winter | 15 | 21 | 28.018 | 1.188 | 13.9 | 3.3803 | 0.0000 | FLOOD RISK |

| Link Event (Outflow) | US Node | Link | DS Node | Outflow (l/s) | Velocity (m/s) | Flow/Cap | Link Vol (m³) | Discharge Vol (m³) |
|---|---|---|---|---|---|---|---|---|
| 15 minute summer | 1 | 1.000 | 2 | 3.5 | 0.489 | 0.647 | 0.0982 | |
| 30 minute winter | 2 | Orifice | 3 | 2.3 | | | | |
| 30 minute winter | 3 | 1.002 | 4 | 12.8 | 0.767 | 1.397 | 0.7348 | |
| 15 minute winter | 4 | 1.003 | 5 | 27.4 | 1.903 | 0.772 | 0.2401 | |
| 15 minute winter | 5 | 1.004 | 29 | 42.2 | 2.792 | 0.895 | 0.0847 | |
| 15 minute winter | 6 | 2.000 | 7 | 5.0 | 0.778 | 0.650 | 0.0786 | |
| 60 minute winter | 7 | Orifice | 8 | 2.1 | | | | |
| 60 minute winter | 8 | Orifice | 9 | 9.4 | | | | |
| 15 minute winter | 9 | 2.003 | 20 | 20.1 | 1.265 | 0.874 | 0.1056 | |
| 15 minute summer | 10 | 3.000 | 11 | 3.6 | 0.490 | 1.512 | 0.0960 | |
| 60 minute winter | 11 | Orifice | 12 | 1.9 | | | | |
| 60 minute winter | 12 | Orifice | 16 | 4.9 | | | | |
| 15 minute winter | 13 | 4.000 | 14 | 7.8 | 0.993 | 1.429 | 0.0961 | |
| 30 minute winter | 14 | Orifice | 15 | 5.5 | | | | |
| 15 minute summer | 15 | Orifice | 16 | 9.9 | | | | |

**Results for 100 year +45% CC +10% A Critical Storm Duration. Lowest mass balance: 99.12%**

| Node Event | US Node | Peak (mins) | Level (m) | Depth (m) | Inflow (l/s) | Node Vol (m³) | Flood (m³) | Status |
|---|---|---|---|---|---|---|---|---|
| 30 minute winter | 16 | 21 | 27.435 | 0.695 | 29.2 | 0.7866 | 0.0000 | FLOOD RISK |
| 30 minute winter | 17 | 23 | 27.129 | 0.239 | 5.0 | 1.8779 | 0.0000 | SURCHARGED |
| 30 minute winter | 18 | 23 | 27.150 | 0.540 | 5.0 | 2.3102 | 0.0000 | SURCHARGED |
| 30 minute winter | 19 | 22 | 27.008 | 0.438 | 31.1 | 6.8954 | 0.0000 | SURCHARGED |
| 600 minute winter | 20 | 480 | 26.661 | 0.261 | 15.1 | 0.2949 | 0.0000 | SURCHARGED |
| 60 minute winter | 21 | 46 | 27.056 | 0.256 | 7.3 | 6.6091 | 0.0000 | SURCHARGED |
| 60 minute winter | 22 | 36 | 27.000 | 0.760 | 5.8 | 3.7653 | 0.0000 | SURCHARGED |
| 600 minute winter | 23 | 480 | 26.660 | 0.580 | 2.9 | 2.3806 | 0.0000 | SURCHARGED |
| 600 minute winter | 24 | 480 | 26.659 | 1.819 | 20.5 | 2.0578 | 0.0000 | SURCHARGED |
| 600 minute winter | 25 | 480 | 26.660 | 0.410 | 1.9 | 1.9914 | 0.0000 | SURCHARGED |
| 600 minute winter | 26 | 480 | 26.660 | 0.700 | 3.3 | 1.9674 | 0.0000 | FLOOD RISK |
| 600 minute winter | 27 | 480 | 26.659 | 1.919 | 25.7 | 284.7318 | 0.0000 | FLOOD RISK |
| 600 minute winter | 28 | 480 | 26.659 | 1.959 | 9.8 | 2.2155 | 0.0000 | SURCHARGED |
| 600 minute winter | 29 | 480 | 26.659 | 2.009 | 9.2 | 2.2717 | 0.0000 | SURCHARGED |
| 600 minute winter | 30 | 480 | 26.658 | 2.028 | 8.5 | 2.2939 | 0.0000 | SURCHARGED |

| Link Event (Outflow) | US Node | Link | DS Node | Outflow (l/s) | Velocity (m/s) | Flow/Cap | Link Vol (m³) | Discharge Vol (m³) |
|---|---|---|---|---|---|---|---|---|
| 15 minute winter | 16 | 3.003 | 19 | 29.1 | 1.652 | 1.655 | 0.3055 | |
| 30 minute winter | 17 | Orifice | 19 | 2.3 | | | | |
| 60 minute winter | 18 | Orifice | 19 | 2.2 | | | | |
| 30 minute winter | 19 | Orifice | 20 | 28.3 | | | | |
| 30 minute winter | 20 | 2.004 | 24 | 46.1 | 1.846 | 0.638 | 0.4675 | |
| 60 minute winter | 21 | Orifice | 22 | 2.4 | | | | |
| 60 minute winter | 22 | Orifice | 24 | 3.8 | | | | |
| 30 minute winter | 23 | Orifice | 24 | 2.4 | | | | |
| 15 minute winter | 24 | 2.005 | 27 | 62.8 | 2.452 | 0.687 | 1.0347 | |
| 30 minute winter | 25 | Orifice | 27 | 2.2 | | | | |
| 30 minute winter | 26 | Orifice | 27 | 2.4 | | | | |
| 15 minute winter | 27 | 2.006 | 28 | -43.9 | -1.365 | -0.504 | 0.4565 | |
| 15 minute winter | 28 | 2.007 | 29 | -42.1 | -0.686 | -0.459 | 0.5171 | |
| 30 minute summer | 29 | 1.005 | 30 | -28.9 | -0.411 | -0.252 | 0.1319 | |
| 720 minute winter | 30 | Orifice | 30_OUT | 7.3 | | | | |

**Results for 100 year +45% CC +10% A Critical Storm Duration. Lowest mass balance: 99.12%**

| Node Event | US Node | Peak (mins) | Level (m) | Depth (m) | Inflow (l/s) | Node Vol (m³) | Flood (m³) | Status |
|---|---|---|---|---|---|---|---|---|
| 180 minute winter | 31 | 136 | 26.868 | 0.128 | 3.8 | 1.5594 | 0.0000 | SURCHARGED |
| 180 minute winter | 32 | 136 | 26.865 | 0.505 | 12.6 | 25.9187 | 0.0000 | SURCHARGED |
| 180 minute winter | 33 | 132 | 26.848 | 0.748 | 8.2 | 3.1595 | 0.0000 | FLOOD RISK |
| 180 minute winter | 34 | 132 | 26.843 | 0.853 | 8.9 | 8.8813 | 0.0000 | SURCHARGED |
| 180 minute winter | 35 | 132 | 26.837 | 0.907 | 6.6 | 2.6725 | 0.0000 | SURCHARGED |
| 360 minute winter | 30_OUT | 296 | 24.701 | 0.091 | 11.3 | 0.1308 | 0.0000 | OK |
| 360 minute winter | 36_OUT | 296 | 24.674 | 0.080 | 11.3 | 0.0000 | 0.0000 | OK |
| 60 minute winter | 37 | 43 | 29.703 | 0.773 | 9.0 | 2.6396 | 0.0000 | FLOOD RISK |
| 60 minute winter | 38 | 43 | 29.699 | 0.899 | 10.1 | 3.5378 | 0.0000 | SURCHARGED |
| 60 minute winter | 39 | 43 | 29.696 | 0.996 | 6.3 | 1.1265 | 0.0000 | SURCHARGED |
| 15 minute summer | 39_OUT | 1 | 28.620 | 0.000 | 3.4 | 0.0000 | 0.0000 | OK |
| 120 minute winter | 40 | 86 | 26.296 | 0.496 | 7.1 | 6.9293 | 0.0000 | SURCHARGED |
| 120 minute winter | 41 | 86 | 26.290 | 0.670 | 7.2 | 7.9681 | 0.0000 | SURCHARGED |
| 120 minute winter | 42 | 86 | 26.283 | 0.733 | 6.8 | 0.8294 | 0.0000 | SURCHARGED |
| 15 minute summer | 42_OUT | 1 | 25.540 | 0.000 | 3.0 | 0.0000 | 0.0000 | OK |

| Link Event (Outflow) | US Node | Link | DS Node | Outflow (l/s) | Velocity (m/s) | Flow/Cap | Link Vol (m³) | Discharge Vol (m³) |
|---|---|---|---|---|---|---|---|---|
| 15 minute winter | 31 | 11.000 | 32 | 12.6 | 1.663 | 0.939 | 0.0563 | |
| 15 minute summer | 32 | 11.001 | 33 | 9.1 | 1.168 | 0.958 | 0.0839 | |
| 15 minute summer | 33 | 11.002 | 34 | 18.7 | 1.221 | 1.068 | 0.1997 | |
| 30 minute winter | 34 | 11.003 | 35 | 18.9 | 1.075 | 1.125 | 0.1174 | |
| 180 minute winter | 35 | Orifice | 30_OUT | 4.9 | | | | |
| 360 minute winter | 30_OUT | 1.007 | 36_OUT | 11.3 | 0.681 | 0.182 | 0.0845 | 490.2 |
| | | | | | | | | |
| 15 minute winter | 37 | 12.000 | 38 | 9.5 | 0.734 | 0.603 | 0.2875 | |
| 30 minute winter | 38 | 12.001 | 39 | 10.1 | 0.688 | 0.284 | 0.0447 | |
| 60 minute winter | 39 | Orifice | 39_OUT | 5.1 | | | | 17.3 |
| | | | | | | | | |
| 30 minute winter | 40 | 13.000 | 42 | -5.8 | -0.736 | -0.871 | 0.1309 | |
| 30 minute winter | 41 | 14.000 | 42 | 10.7 | 1.371 | 1.908 | 0.0180 | |
| 120 minute winter | 42 | Orifice | 42_OUT | 4.4 | | | | 32.2 |

## Appendix J: SuDS Management & Maintenance Schedule

## Nile & Villiers - SuDS Maintenance Schedule

**Rev 02 - 09/10/2023**

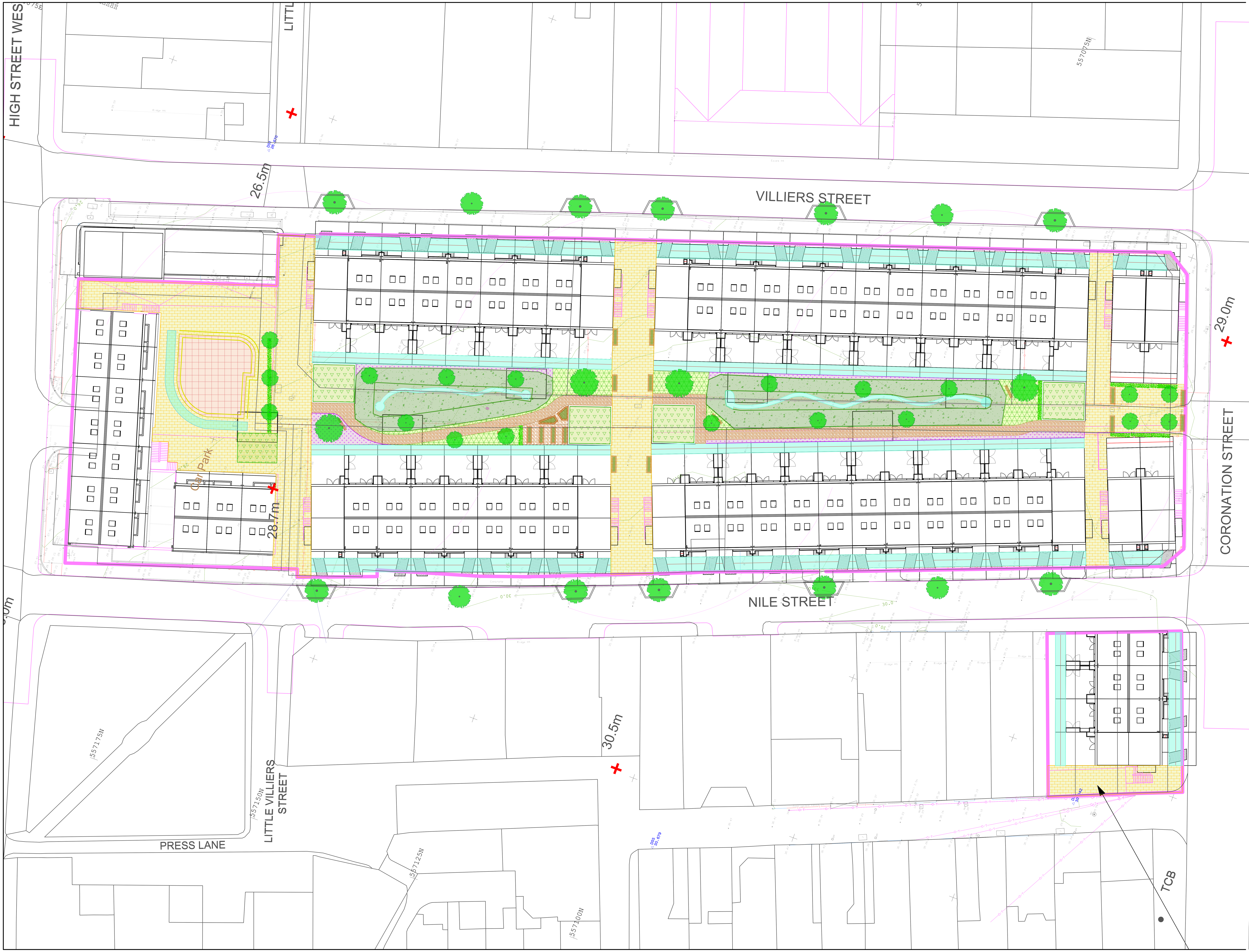
**For Planning**

The below table is extracted from The SuDS Manual 2015 (CIRIA C753)

| Activity / Maintenance Schedule | Required Action | Frequency | Maintenance Responsibility |
|---|---|---|---|
| **Bioretention Systems** | | | |
| Regular inspections | Inspect infiltration surfaces for silting and ponding, record de-watering time of the facility and assess standing water levels in underdrain (if appropriate) to determine if maintenance is necessary | Quarterly | Development management team |
| | Check operation of underdrains by inspection of flows after rain | Annually | |
| | Assess plants for disease infection, poor growth, invasive species etc and replace as necessary | Quarterly | |
| | Inspect inlets and outlets for blockages | Quarterly | |
| Regular maintenance | Remove litter and surface debris and weeds | Quarterly (or more frequently for tidiness or aesthetic reasons) | |
| | Replace any plants, to maintain planting density | As required | |
| | Remove sediment, litter, and debris build-up from around inlets or from forebays | Quarterly to biannually | |
| Occasional maintenance | Infill any holes or scour in the filter medium, improve erosion protection if required | As required | |
| | Repair minor accumulations of silt by raking away surface mulch, scarifying surface of medium and replacing mulch | As required | |
| Remedial actions | Remove and replace filter medium and vegetation above | As required but likely to be > 20 years | |
| **Pervious Pavements** | | | |
| Regular maintenance | Brushing and vacuuming (standard cosmetic sweep over whole surface) | Once a year, after autumn leaf fall, or reduced frequency as required, based on site-specific observations of clogging or manufacturer's recommendations – pay particular attention to areas where water runs onto previous surface from adjacent impermeable areas as this area is most likely to collect the most sediment | Development management team |
| Occasional maintenance | Stabilise and mow contributing and adjacent areas | As required | |
| | Removal of weeds or management using glyphospate applied directly into the weeds by an applicator rather than spraying | As required – once per year on less frequently used pavements | |
| Remedial actions | Remediate any landscaping which, through vegetation maintenance or soil slip, has been raised to within 50 mm of the level of the paving | As required | |
| | Remedial work to any depressions, rutting and cracked or broken blocks considered detrimental to the structural performance or a hazard to users, and replace lost jointing material | As required | |
| | Rehabilitation of surface and upper substructure by remedial sweeping | Every 10 to 15 years or as required (if infiltration performance is reduced due to significant clogging) | |
| Monitoring | Initial inspection | Monthly for three months after installation | |
| | Inspect for evidence of poor operation and/or weed growth – if required, take remedial action | Three-monthly, 48 h after large storms in the first six months | |
| | Inspect silt accumulation rates and establish appropriate brushing frequencies | Annually | |
| | Monitor inspection chambers | Annually | |
| **Detention Basins** | | | |
| Regular maintenance | Remove litter and debris | Monthly | |
| | Cut grass – for spillways and access routes | Monthly (during growing season), or as required | |
| | Cut grass – meadow grass in and around basin | Half yearly (spring – before nesting season, and autumn) | |
| | Manage other vegetation and remove nuisance plants | Monthly (at start, then as required) | |
| | Inspect inlets, outlets, and overflows for blockages, and clear if required | Monthly | |
| | Inspect banksides, structures, pipework etc for evidence of physical damage | Monthly | |
| | Inspect inlets and facility surface for silt accumulation. Establish appropriate silt removal frequencies. | Monthly (for first year), then annually or as required | |
| | Check any penstocks and other mechanical devices | Annually | |

| Activity / Maintenance Schedule | Required Action | Frequency | Maintenance Responsibility |
|---|---|---|---|
| | Tidy all dead growth before start of growing season | Annually | Development management team |
| | Remove sediment from inlets, outlet and forebay | Annually (or as required) | |
| | Manage wetland plans in outlet pool – where provided | Annually | |
| Occasional maintenance | Reseed areas of poor vegetation growth | As required | |
| | Prune and trim any trees and remove cuttings | Every 2 years, or as required | |
| | Remove sediments from inlets, outlets, forebay and main basin when required | Every 5 years, or as required (likely to be minimal requirements where effective upstream source control is provided) | |
| Remedial actions | Repair erosion or other damage by reseeding or re-turfing | As required | |
| | Realignment of rip-rap | As required | |
| | Repair/rehabilitation of inlets, outlets, and overflows | As required | |
| | Relevel uneven surfaces and reinstate design levels | As required | |
| **Attenuation Storage Tank** | | | |
| Regular maintenance | Inspect and identify any areas that are not operating correctly. If required, take remedial action | Monthly for 3 months, then annually | Development management team |
| | Remove debris from the catchment surface (where it may cause risks to performance) | Monthly | |
| | For systems where rainfall infiltrates into the tank from above, check surface of filter for blockage by sediment, algae or other matter; remove and replace surface infiltration medium as necessary | Annually | |
| | Remove sediment from pre-treatment structures and/or internal forebays | Annually, or as required | |
| Remedial actions | Repair/rehabilitate inlets, outlet, overflows and vents | As required | |
| Monitoring | Inspect/check all inlets, outlets, vents and overflows to ensure that they are in good condition and operating as designed | Annually | |
| | Survey inside of tank for sediment build-up and remove if necessary | Every 5 years, or as required | |
| **Conventional drainage systems & flow control devices** | | | |
| Regular maintenance | Remove litter and debris | Monthly (or as required) | Development management team |
| Occasional maintenance | Monitoring | Inspect monthly (and after large storms) | |
| | Sediment management. Removal of accumulated silt from system. | Annually or as required | |
| Remedial actions | Structure rehabilitation/repair | As required | |

## Appendix K: Landscape Masterplan




NOTE:
Notes

## Key

- Amenity SuDS basin
- Rain gardens
- Urban SuDS basin
- Green roof
- Mown grass
- Wildflower planting
- Self binding gravel path
- Permeable brick paving
- Planter
- Bench
- Tree
- Hedge

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Project
Nile & Villiers Street
Sunderland

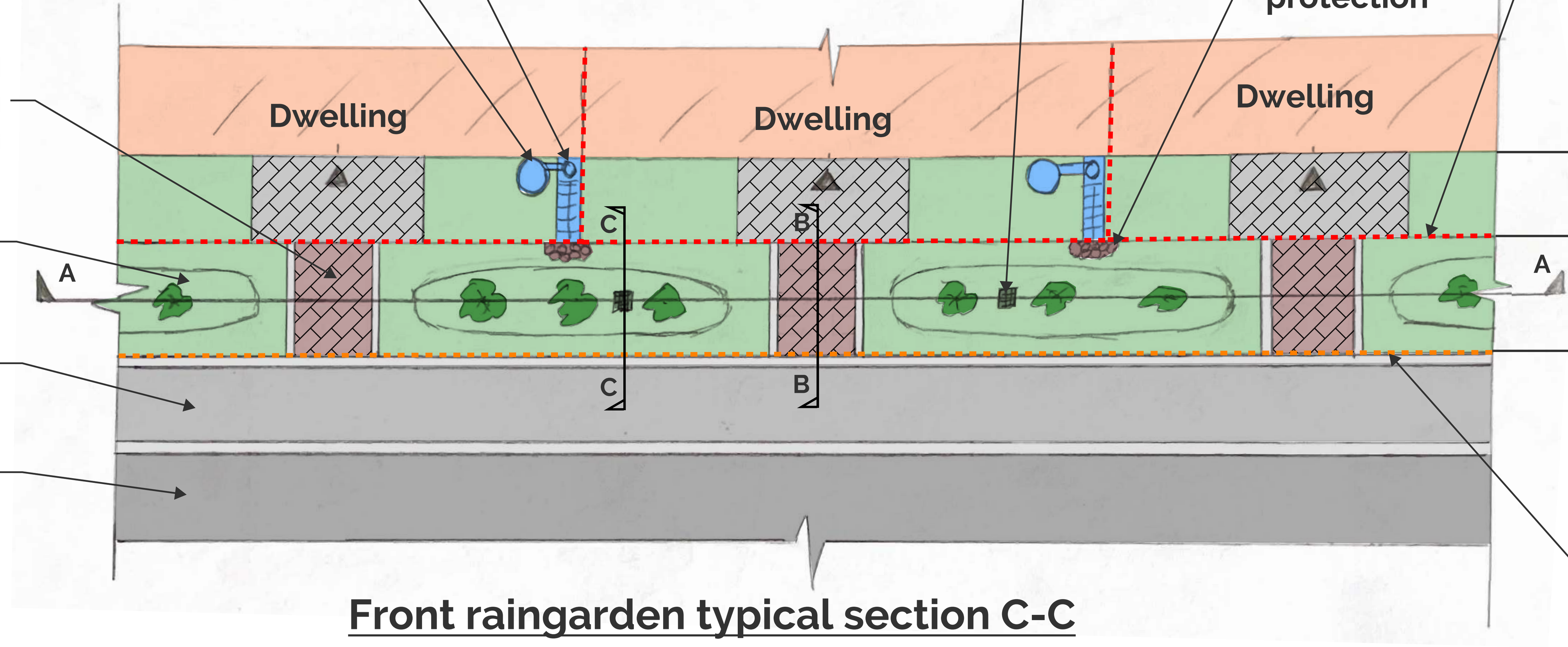
Drawing title
Landscape General Arrangement Plan

| Date | Scale @A1 | Dwn. |
|---|---|---|
| September 2023 | 1:250 | GP |

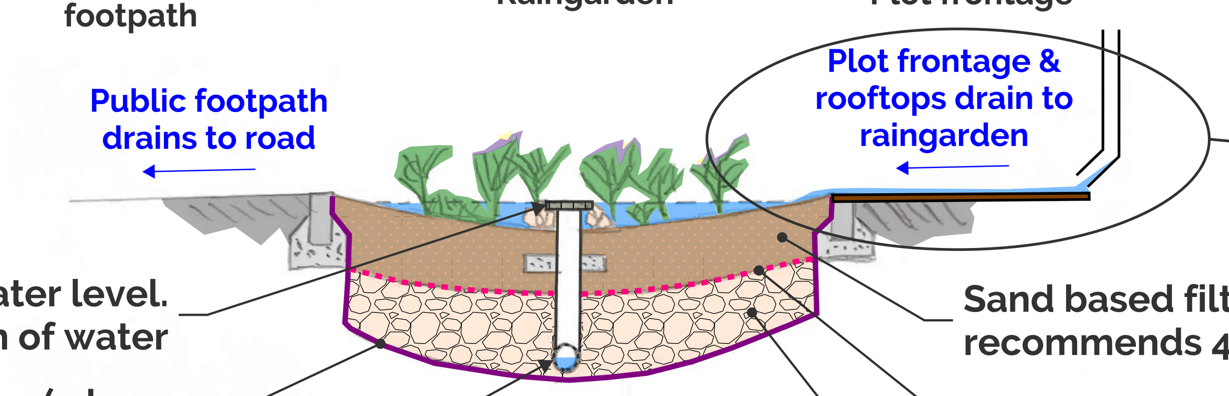
| Drawing number | Rev. |
|---|---|
| SUN005-SK-001 | A |

## Appendix L: SuDS Sketches

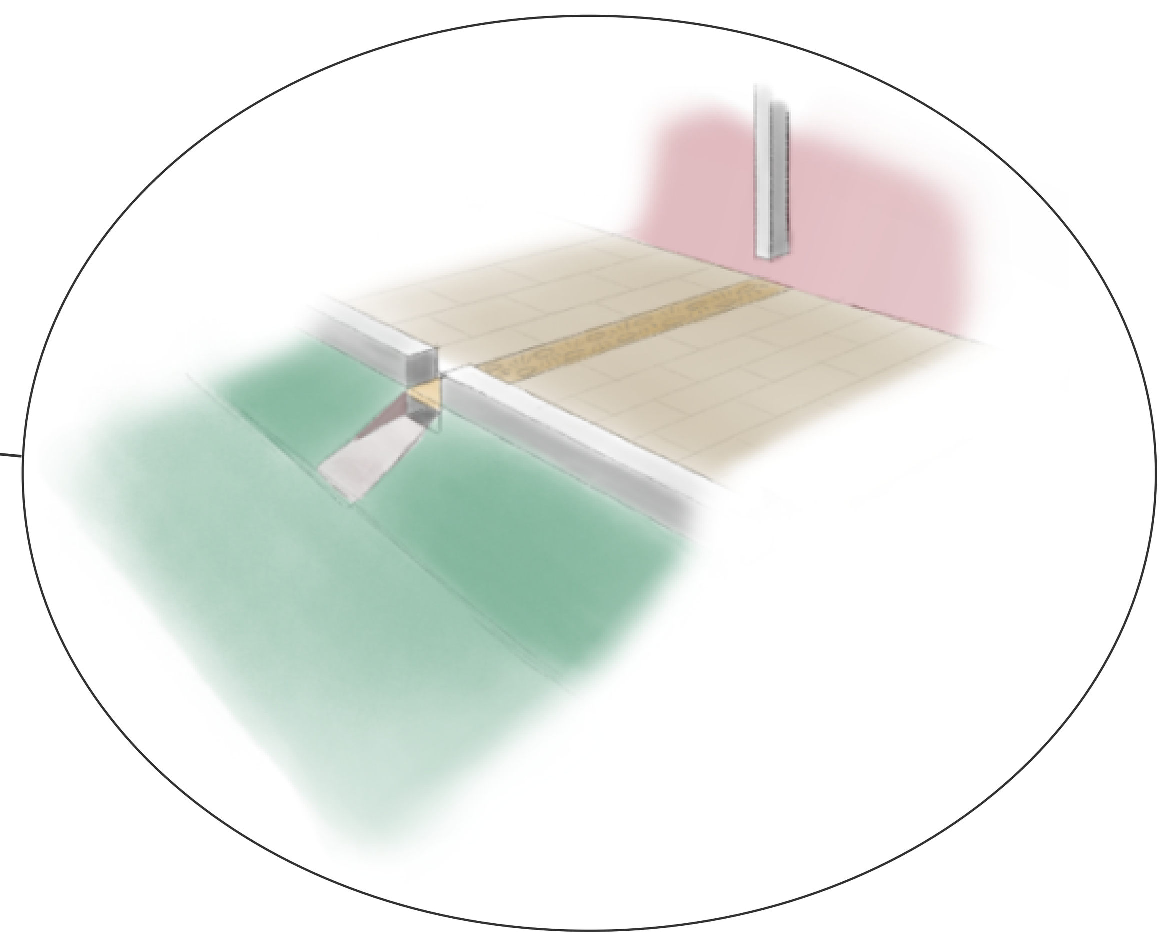
# Raingarden to plot frontages - plan sketch



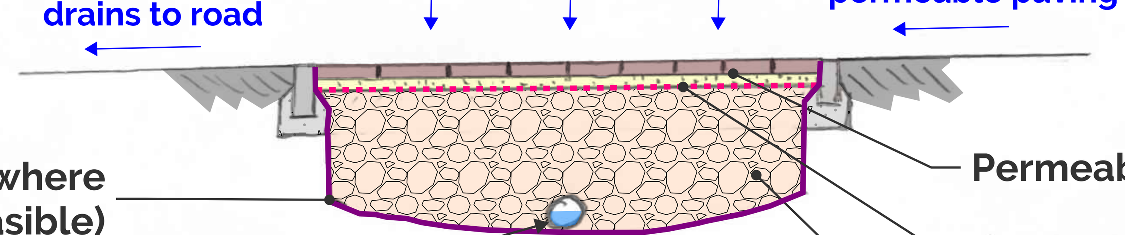

## Front raingarden typical section C-C



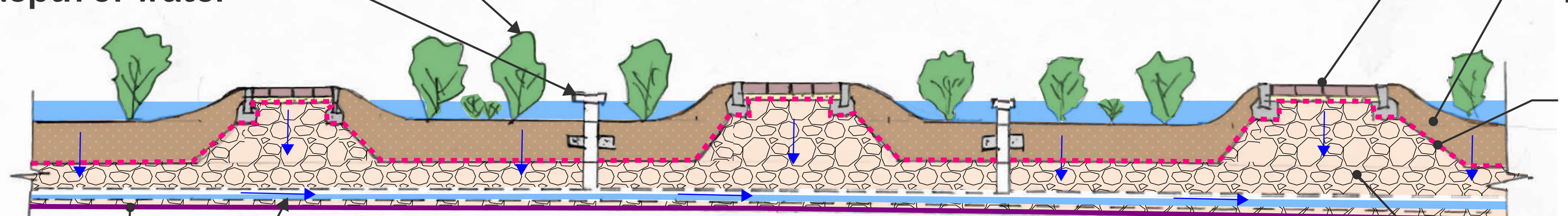

## RWP CONNECTION TO RAIN GARDEN SKETCH



## Front access crossing raingarden typical section B-B

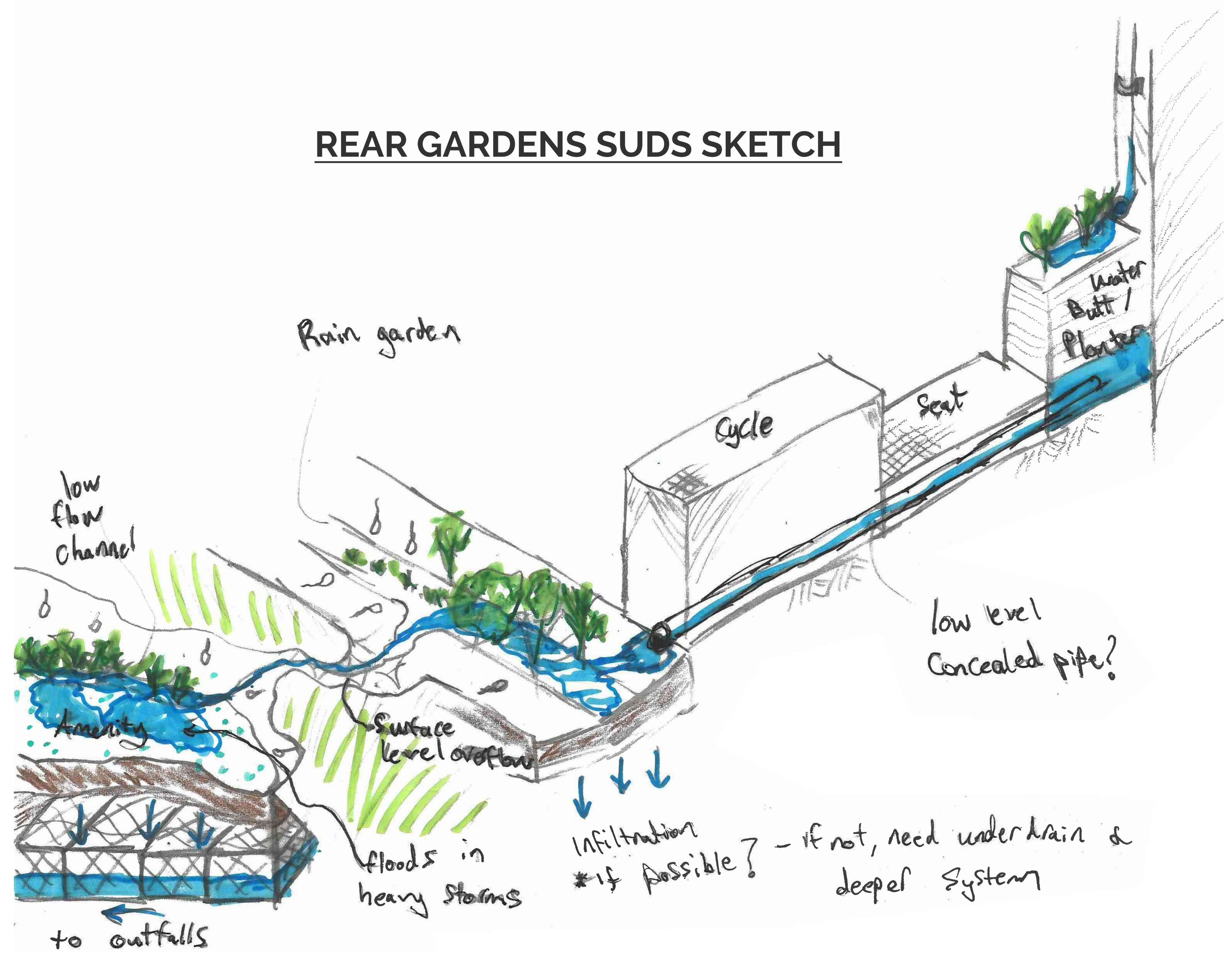



## Raingarden long section A-A




*Geo-cellular crates could be introduced at the base of the system to provide additional surface water attenuation.
**The type of planting i.e. ground cover vs shrubs vs trees will impact the depth of soil and overall depth of the system. Trees may require structural tree pits (based on proximity to road) as well as root barriers and their impact on foundations would need assessing.

## REAR GARDENS SUDS SKETCH

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2. THIS DRAWING SHOULD NOT BE SCALED.
3. ALL DIMENSIONS ARE TO BE VERIFIED BY THE CONTRACTOR ON SITE.
4. ALL DISCREPANCIES SHOULD BE REPORTED TO C.A./E.A. PRIOR TO THE COMMENCEMENT OF WORKS.



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