TEICNIUIL-PRIORY CONSULTING ENGINEERS Ltd

Engineering Assessment and Drainage Design Report

Project: Proposed Housing Development at Ardshanvooley, Park Rd, Killarney

Client: Wrightwood Development Ltd

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Appendix B - Conveyancing Pipework outlet to Suds Component / flow rates
Appendix C - Tencate 'Geoclean' Aqua textile Data Sheet
Appendix D – Summarized Hydraulic Flow Calculations

Associated Documents/Reports (annexed to this report)

Soil Infiltration Report
Site Specific Flood Risk Assessment Report (by Others)
Calculation Sheet Document

Drawings

See Drawing Regist

1.0 Introduction

This report details the stormwater drainage design, which includes 'Sustainable Urban Drainage Systems' (SuDs methods), foul water drainage design, and water supply measures to be implemented as part of the proposed Housing Development consisting of 124No Housing units, to be constructed on a greenfield site, measuring c. 2.23Ha, located at Ardshavooley, Killarney, Co, Kerry.

2.0 Qualifications and Experience

Teicniuil-Priory Consulting Engineers Ltd have been commissioned to carry out the Civil Engineering Design Works of this proposed development, including the undertaking the role of 'Assigned Certifier', on behalf of the developer, Wrightwood Development Ltd.

The writer, Matt Clarke, Principal within Teicniuil-Priory Consulting Engineers, is a Chartered Engineer with over 25 years of Engineering experience including Drainage Design and SuDs assessments

He holds the following professional accreditations:

Fellow of the Association of Building Engineering
Member of the Institution of Engineers of Ireland
Member of the Chartered Institution of Building
Registered Building Surveyor with the Society of Chartered Surveyors Ireland

3.0 Location of Site

Address:

Lands located within the Townland of Ardshanavooly, Killarney, Co. Kerry

Coordinates:

ITM: 494050, 591356

GPS: 52°, 03’52.12’’ N, 9°, 30’ 05.32’’ W

This site is located approximately 0.9km from Killarney Town Centre, and is in close proximity to various amenities – many within walking distance. Several small housing estates already exist to the South of the site. A proposed housing estate is also earmarked, by others, to the East of the site, under separate development works.

The site consists of existing grazing farmland. (habitat: GS2 – ‘dry meadows and grassy verges’ – ‘Guide to *Habitats in Ireland – The heritage council)*, and is gently sloped, in a general North-to-South direction, presenting a gradual average slope of approximately 1:60. Clear boundaries are present; substantial earthen mounds exist, with some planted with mature trees, on the Northern and Eastern boundaries. A smaller earthen mound planted with a tree line is also present adjacent a small road on the Western boundary. A concrete panel fence-type structure exists to the South, forming the boundary of an existing housing development.

The extent of the site is outlined in red on the extracted topographical survey, in fig 1, below and on the aerial photograph shown in fig 2, below. (also see drawing register, for relevant drawings).

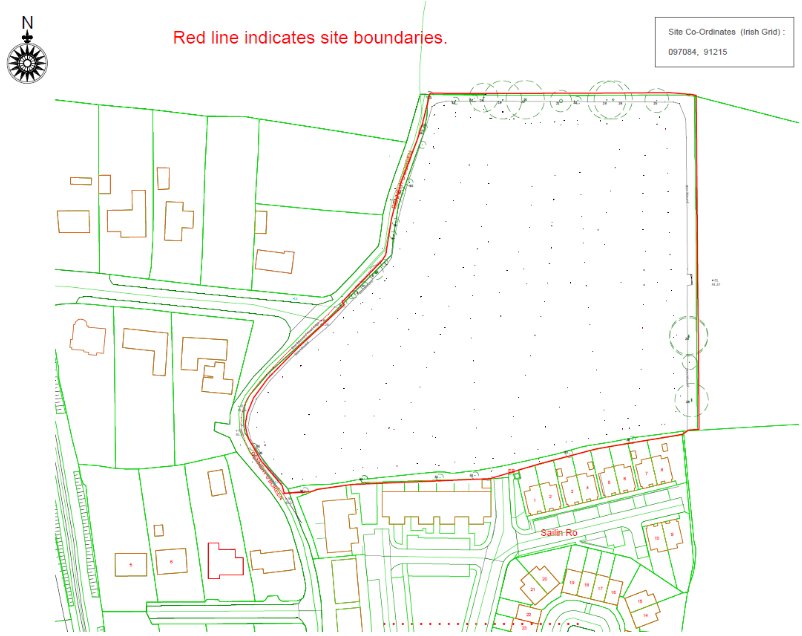

Fig 1 - Extract from Topographical Survey – Proposed Development Site Outlined in Red
(Refer to Topographical Survey drawing (drwg No 91-24-0-001 Rev A)

Fig 2 – Aerial Photograph – Proposed Development Site Outlined in Red

4.0 Development Description:

Development at a 2.23 hectare site comprising of:

1. Construction of a 124 no. dwellings in a mix of duplex, maisonette and apartment typologies comprising 16 no. 1 bed apartments, 6 no. 2 bed apartments, 16 no. 1 bed duplex apartments, 16 no. 2 bed duplex maisonettes, 33 no. 2 bed duplex apartments, 33 no. 3 bed maisonettes and 4 no. 3 bed terrace houses, all in building heights ranging from 2 to 4 storeys.

2. A total of 143 no. surface car parking spaces, including 4 no. car-share parking spaces, 6 no. visitor spaces, and 5 no. assigned Part M/accessible spaces.

3. Bicycle parking comprising of 272 no spaces in total, comprising 118 no. spaces within the private open space of ground floor residential units and 102 no. spaces within secure sheltered structures and designated secure bicycle parking areas, and 52 no. short stay/visitor spaces.

4. 3,642 sq.m of public open space, including arrival pocket park, central pocket park and amenity landscape areas (including 126 sq.m of play), grass lawns, kickabout areas, picnic areas and seating areas;

5. 844 sq.m of communal external open space, including seating areas, nature trails, and amenity grass lawns, plus 86 sq.m internal community space associated with the apartment block.

6. Additional environmental open space, including landscape buffers, protection and enhancement of existing hedgerows and trees.

7. A new vehicular, pedestrian and cyclist access from the existing estate road adjoining the site to the south.

8. Infrastructure works to serve the proposed development to include the internal road and footpath network, ESB cabinets/substations/switchrooms, site and external building lighting, site drainage works, hard and soft landscaping, boundary treatments, communal bin stores, and all ancillary site services and development works above and below ground.

5.0 Soil Characteristics / General Geology and Hydrology

The soil characteristics of this site are detailed in the associated 'Soil Infiltration Report', which includes a detailed description of the geology and hydrology of the site. The reader is also referred to the Site Specific Flood Risk Assessment Report, by others.

Various geological and hydrological maps (GSI mapping) are also presented in the Soil Infiltration report.

In summary, the following was noted;

Ground water aquifer: Regionally Important Gravel Aquifer

Ground water Vulnerability: High

Subsoil Permeability: High

Teasgasc EPA Soil: Shallow well Drained (A_{minsw}), Parent material: Glaciofluvial sands and gravels (GDSs)

Subsoil: Gravel derived from Devonian Sandstones (GDSs)

Bedrock: Dirtoge Limestone Formation (CDDRTG) – Bioclastic herty grey limestone

Surface Water Features: None within 250m from site perimeter

Wells and Springs: No wells or springs within 250m from site perimeter.

Groundwater Protection Scheme IE_GSI_GWPS_Rep_11

Karst Features: no karst features within 250m of site perimeter

5.1 On-site Soil Infiltration testing

A full description of the soil investigation is given in the 'On-site Soil Infiltration Testing Report' annexed to this Engineering Assessment and Drainage Design Report.

In summary, upon trial hole excavation, the subsoil was found to consist of a slightly silty/sandy gravel, with sporadic cobbles (<200mm dia), described in the general 'soil build-up', as follows;

Horizon A: 250mm BGL of organic top soil
Horizon B: 250mm to 800mm of slightly silty sandy gravel, with some sporadic cobbles (< 200mm dia)
Horizon C: 800mm to Base of pit (between 1.9m and 2.65m slightly silty sandy gravel, with some sporadic cobbles (< 200mm dia)

On-site testing was conducted to BRE 365 Soakaway Design Guidelines, and the soil infiltration rates were found to be between $58.8x10^{-6}$m/s and $122.0x10^{-6}$m/s. These represent good infiltration characteristics, indicative of the soil type observed on-site, and as expected from both the Geological Mapping desk study and the writer's local knowledge of the area.

No evidence of Ground Water was noted in any trial hole. The water table is deemed > 5m in depth.

The above data corresponds with known site conditions within adjacent lands, and indicates that the site is suitable for infiltration design, with protective measures.

5.2 Flood Risk

Review of the CFRAM maps shows that there is no fluvial flooding risk within this site. No surface water features exist within 250mm of this proposed development site.

There is no evidence of any previous flooding on this site.

The depth of the water table (>5m) indicates there is no propensity for Groundwater flooding.

A Site Specific Flood Risk Assessment (SSFRA) has been carried out by others. There is no identified historic or predicted fluvial, coastal or groundwater flooding within the site. The reader is referred to the SSFRA annexed to this report.

6.0 Surface Water drainage

6.1 SUDS overview

A Sustainable Urban Drainage System (SUDS) is to be designed and incorporated into the development.

SUDs is been defined as "*a way of managing rainfall that minimizes the negative impacts on the quantity and quality of run-off while maximizing the benefits of amenity and biodiversity for people and the environment. " - CIRIA C753, 'The SUDS Manual' 2015.* This guidance document will be referred to as 'the SUDs Manual' throughout this report.

The design philosophy of SUDs is to manage and control surface water drainage by providing Nature Based Stormwater Solutions, which mimic the natural drainage regimes of a greenfield site.

This philosophy is encapsulated in the '4 pillars' of SUDs design, for which the criteria are;

1. <u>Quantity</u>
    - Manage and control run-off flow rates from impermeable areas, and prevention of flooding
    - Support evapotranspiration from planting / vegetation
    - Encourage groundwater recharge
2. <u>Quality</u>
    - Provide measures to reduce pollution in stormwater, by providing a 'treatment train' in the stormwater conveyance process
    - Protect groundwater / aquifers
    - Protect surface watercourses

3. <u>Amenity</u>
    -natural 'soft' SUDs solutions provides increased connection with nature
    -aesthetically pleasing
    -increase amenity 'play' areas
    -Provides more 'natural' landscape within the urban context

4. <u>Biodiversity</u>
    - provide habitats for flora and fauna
    -encourages engagement with wildlife.
    -assists with carbon reduction

The above is summarized in the following diagram;

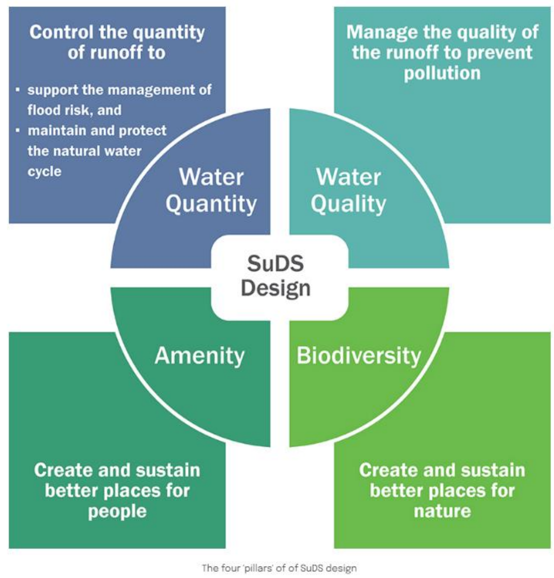

Fig 3 – '4 pillars' of SUDs Design

6.2 Kerry County Council Development Plan (2022 – 2028)

It is a policy of Kerry County Council to promote biodiversity, the use of SUDs, and other nature-based solutions in the design, construction, and maintenance of residential developments. (*6.2.3 – Housing for sustainable communities)*

The following Objectives regrading storm water management are cited, within the Development Plan, as follows;

"KCDP 13-21 The improvement of sustainable drainage and reduce the risk of flooding in the urban environment in accordance with the CIRIA SuDS Manual 2015."

Proposed implementation; Throughout this Drainage Engineering Assessment report, design guidance refers to The SUDs Manual.

"KCDP 13-22 It is an objective of the Council to identify opportunities for nature-based SuDs in tandem with the preparation of masterplans for urban areas and plan level Strategic Flood Risk Assessments.

Proposed implementation ; Nature based SUDs , commonly referred to as 'soft' SUDs is to be incorporated into this proposed development. It will be shown, within this report, that there is no Flooding Risk associated with this proposal.

"KCDP 13-24 Support the incorporation of Sustainable Urban Drainage Systems (SUDs) in all public and private development in urban areas. "

Proposed implementation; Both ‘hard’ and ‘soft’ SUDs measures will be incorporated within the design and surface water management strategies, within the proposed development. It is proposed that no surface water will be discharged from the site into the existing public drainage network. (ie whole site infiltration)

“KCDP 13-25 Work alongside Irish Water to ensure the separation of foul and surface water drainage networks where feasible and undertake drainage network upgrades to help remove surface water misconnection and infiltration”

Proposed implementation ; A feasibility application has been submitted to Irish Water regarding the proposed foul water drainage. The foul water drainage system, which will be completely separated from the storm water drainage system, will be designed and constructed to Irish Water Standards. It is proposed to treat all surface water on-site. A Confirmation of Feasibility has been received from Irish Water. (Appendix A).

In line with KCDP ‘*Storm Water Management’,* the following has been considered

All SUDs components and the storm water conveyancing network has been designed with a 20% Climate Change Factor, to allow for more frequent and intense rainfall.

The SUDs design, as proposed, considers infiltration techniques via a combination of both nature-based solutions (‘soft’ Suds) and ‘hard’ suds solutions, being geo-cellular systems. The proposed design layout shows a general ‘even-spread’ of selected SUDs components, throughout the overall site, which replicates, as close as possible, the natural drainage processes, with final discharge to ground water and ensures groundwater recharge.

Additionally, the incorporation of nature-based SUDs solutions promotes the design philosophy of the aforementioned ‘4 pillars of SUDs Design’.

Should any controlled surface water flow discharge from the site be required, this will be limited to greenfield run-off rates. (see calculation report).

Various SUDs proposals, are outlined below. Included within these proposals are source control measures including permeable paving, bioretention / raingardens, tree pits, and soakaways. *(cl 4.31 Sustainable Residential Development in Urban Areas (2009 DoEHLG)).*

6.3 SUDs Methods

A sequence of SUDs components, forming a ‘management train’ is to be provided, which will control flow velocities and limit pollutants within the storm water.

Methods of Discharge Routes Considered

A number of discharge options have been considered for this development proposal, namely:

- Soakaways
- Attenuation tanks / crates
- Attenuation Ponds
- Swales
- Permeable Paving
- Infiltration Blanket
- Bioretention Areas
- Green Roofs
- Rainwater harvesting
- Tree pits
- Detention basin

For infiltration methods, calculated soil infiltration rates, as obtained from on-site soil infiltration testing will form the basis of design, specification, and sizing for proposed infiltration methods. , (see Soil Infiltration Testing Report).

These methods are reviewed and considered as follows;

Soakaways

There is scope within the confines of the site, for a soakaway design, discharging to the underlying soil. The soil has good infiltration characteristics, (> 10^-6m/s), and the water table is located at a depth >5m.

A propriety modular crate system, or similar, would be suitable. These systems have a void ratio of between 95% and 100%, depending on product selected. Some proprietary solutions also combine suitable drainage stone (MOT type 3, cl 805) with a 30% void ratio, fully enclosed by a permeable geotextile material, as part of the installation.

Given the geological assessment of the site, and noting the site area is within a '*Regionally Important Gravel Aquifer*', a suitable treatment train is crucial for the treatment of the storm water, regarding soakaways, or any infiltration method adopted. Predominantly, silt and other pollutants are most likely to enter the system via vehicular trafficked areas. (see Ground Water Protection Measures in section 6.5.3)

As part of the 'treatment train', silt traps are generally to be included, prior to discharge to the underground soakaway. Additionally, the 'above ground' rainwater system from the roofs of buildings (ie rainwater down pipes, to gullies), are to be designed as an 'open' system which will require gulley pots to act as a silt trap, to trap any debris encountered from the roof, as a 'first treatment', prior to entering a main silt trap. This water will contain a very low level of pollutants. (see section 6.5.2 – water quality)

Drainage conveyancing pipework from the individual roof aspects will discharge into 6No separate soakaway areas, which are to be dispersed around the site. (see Conveyancing Pipe outlet Flow Summary Sheet – Appendix B). The dispersion of soakaways around the site, allows for a 'spread' of generally a uniform infiltration to the subsoil, which, along with other infiltration techniques, mimics the natural site and allows for ground water recharge throughout the extent of the site area . Locations of soakaways are to be incorporated within the proposed 'Green' areas.

Generally, water run-off from the road system are more likely to contain higher pollutant indices than roofs, (see section 6.5.2 – Water quality).

All soakaways are to be a minimum of 5m from any building foundations.

Attenuation tanks / crates

There is scope within the confines of the site for surface water attenuation & discharge to the existing public storm water system, via a flow control device. (ie hydrobrake or orifice plate). Such a system would limit the discharge flow to pre-development greenfield site conditions.

Given the configuration of the site, and placement of 'green areas', various clusters of attenuation crates / tanks would have to be utilized, all interconnected, with final outlet via a flow control device. This is not deemed to be economically effective.

Additionally, the SUDS Manual recommends that infiltration viability should be given full consideration where the infiltration rate is 10^-6 or greater. The lowest infiltration rate measured on the site is 55.8 x 10^-6. Therefore, infiltration methods should be considered, which would allow full treatment of stormwater on site, resulting in zero discharge flow to the public sewer. Attenuation calculations show that the limiting greenfield flow rate at, 0.2L/s = 1.4L/s for a 100 year return period (See Calculation Sheet), which would result in large attenuation volumes on site, translating in increased installation costs and reduced flexibility of overall design layout. Assuming the provision of adequate protection of groundwater, then infiltration methods are the preferred solution compared with attenuation techniques.

Swales

The incorporation of swales is possible within the site. The provision of various green areas within the site, provides suitable locations for a swale system, positioned adjacent to, and parallel with, footpaths. The 'SUDs Manual' recommends that to maximize water quality benefits, that swales are a minimum of 30m in length.

Swales maybe utilized to take stormwater run-off from the footpaths, as a primary storage and treatment.

Referring to The SUDS Manual, cl 17.4.1 – 'Swales', the following is recommended;

Swale depths are to be shallow, (<100mm depth, with a typical width of approx. 2.5m – depending on catchment area). The maintenance of swales can be easily incorporated into the general maintenance of green areas. Flow velocities for extreme events are to be kept low (<1.0m/s) and the design depth of water within the swale is to be < 100mm, to allow for effective filtration.

Maximum flow in swale is to be limited to 0.3m/s, and the residence time (length of swale/velocity) to be a minimum of 9mins, to ensure the adequate pollutant removal performance required for run-off events occurring about once a year (i.e. 1:1 year return events), as detailed in the SUDs Manual.

Attenuation ponds:

While an attenuation pond is a viable option for sustainable drainage, it is not considered an option in this circumstance, due to the relatively small size of the available 'green' areas, the unsuitability of same close to dwellings, Health and Safety considerations within a residential development, and the availability of other, more suitable options of sustainable stormwater drainage.

Permeable paving

The soil conditions as described above, and within the Soil Infiltration Testing Report, annexed to this report, are conducive to infiltration rates required for permeable paving. Permeable paving, under carparking areas, is relatively common, although cognizance must be taken within the design, to prevent potential of hydrocarbons and other pollutants, from infiltrating to the groundwater, given the classification of aquifer present within this site. However, there is a substantial subsoil layer between the stone base of the permeable paving, and the water table (>5m). The SUDs Manual requires a minimum of 1.0m of unsaturated subsoil between the invert of the infiltration base and water table. The actual unsaturated sub-soil depth is in excess of 5m. Additionally, while good infiltration rates have been measured for this site (highest rate being 122 x 10^-6m/s), this is not overly fast, and would filter any pollutants within the water. There also is no evidence of a fractured soil, nor any karst features within, or near the site, nor any evidence of boulders (ie >600mm dia) within the soil, all of which would limit the removal of any pollutants, due to possible localized high infiltration rates. Additionally, specialist oil-biodegrading geotextiles may be incorporated below the pavement sub-base layer, which mitigate against hydrocarbons, and other pollutants entering the soil, (Appendix C – product data for specialist geotextile proposed – Tencate 'Geoclean' aquatextile.)

The permeable pavement surface considered is of a modular paving type; a concrete block permeable paving (CBPP) is proposed, which offers an attractive differentiation of surface appearance between the road and designated carparking areas. (appendix C). 'Grasscrete' is a viable alternative option.

The general build-up of Concrete Block Permeable Paving, is as follows:

65mm concrete block paving units

40mm of grit bedding layer (grit 2mm<dia<6mm)
Specialist Geotextile (*Geoclean aquatextile) membrane (appendix C)*
250mm MOT type 3 cl 805 stone (30% void)
Specialist Geotextile (*Geoclean aquatextile) membrane (appendix C)*
Subgrade

Note: 2No layers of the geotextile enhances the water treatment efficiency (Appendix C).

<u>Structural design of pavement</u>

Due to the good infiltration characteristics of the soil, very little drainage stone is needed under the permeable paving. (See Calculations). Therefore, the minimum depth of road sub-base, is based on structural considerations, rather than storage volume requirements. From soil trial hole inspections, a firm sandy gravel soil is noted, which equates to a nominal CBR of 7% (table 20.4 SUDs manual), although from observation, CBR value is likely to be considerably more. A CBR of 7% gives a minimum required depth of subbase of 150mm, for a lightly trafficked road. The actual depth to be minimum 200mm under the perimeter permeable paved areas, to allow for occasional heavy commercial or emergency vehicles.

Permeable paving, due to the uniform infiltration per unit area, which mimics greenfield infiltration, is permitted to be constructed immediately adjacent to buildings. The type of soil within the site (sandy gravel), is ideal for this SUDs method.

<u>Infiltration Blanket</u>

This is a drainage stone layer, for which the stormwater directly infiltrates to the ground. The area and depth of such a layer, is dependent on the area (ie quantity of storm water flow) of impermeable sub-catchment considered. This depth of stone provides the required attenuation requirements.

However, such systems, as is the case for soakaways, are required to be a minimum of 5.0m from foundations. The space constrictions of the site would generally limit the use of infiltration blankets, and a more 'compact' and economical solution would be provided via geo-cellular soakaways, having a higher void ratio.
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<u>Bioretention areas</u>

Bioretention areas, are small depression areas, which are generally 'dry', but are designed to temporarily fill with storm water to 150mm deep, during excessive storm water events. A sandy soil medium is overlain a drainage bed. This soil medium is usually a minimum of 300mm to 600mm depth where selected planting is considered or 1000mm depth if tree planting is proposed. Soil media and proposed planting is to be specified by a Landscape Architect.

These are a 'Soft Suds' method of storm water treatment, and can provide an ecological and attractive visual benefit, and are efficient at removing any pollutants from the water. (see section 6.5.3) Such systems can either be designed to provide direct drainage to the subsoil, via infiltration methods, or be provided with an underdrain, incorporated within the drainage bed, and connected to a remote discharge location. A 'rain garden' is a relatively small and aesthetically pleasing form of a bioretention area, that would be suitable at appropriate locations around this development.

These are effective in providing an attractive landscape feature, as well as habitat and diversity for flora and fauna.

Green Roofs

Green roofs are not proposed within this development. It is not considered viable to introduce green roofs into the design of these housing units, many of which are apartments and duplexes.

Rain water harvesting

It is not considered viable to provide underground tanks for the purposes of rainwater harvesting, to individual dwelling units, and would be almost impossible to provide same for apartment use. However, where possible, the provision of water butts within the rear garden of housing units could be considered. The sloped roof of some of the houses could discharge to water-butts, and assist with sustainable use of rainwater. However, this method is not included in the SUDS design proposal, and would be at the discretion of the end user / homeowner.

Tree pits

Tree pits, or planters, can be provided, which would collect and temporarily store a small amount of stormwater run-off, and such pits could also be provided within the shallow swales, or within and around proposed footpaths. These are also a 'soft' suds method of storm water management, and are a form of bioretention. These pits would also filter any pollutants within the water. It would be desirable to incorporate such methods into the overall development, which would also have ecological benefits and improve the overall visual amenity of the area. Tree pits are proposed to treat the storm water discharge from some of the road aspect.
Silt trap gulleys may be used prior to tree pit inlet, taking a limited amount of road sub-catchment which would discharge directly to the tree pit.
Alternatively, open channel flow, straight from the road surface, can be directed into the respective tree-pits. An allowance for progressive siltation should be incorporated into the design, in the sizing of these tree-pits. This latter option is a preferred SUDs choice, incorporating 'open channel' flow into the respective pit, and removing the requirement of gulleys and pipework.

Detention Basins

Detention basins are landscape depressions that are usually dry. During times of storm events these depressions may fill / pond with water which provide storage and flow attenuation. They can either be on-line or off-line, depending on drainage configuration. These depressions are normally vegetated. Such vegetated depression basins are a 'Soft Suds' method of storm water treatment, and can provide an ecological and attractive visual benefit, and are efficient at removing any pollutants from the water.

Petrol / Oil Interceptor

An oil interceptor can form part of the treatment train. Typically, interceptors are used for car parks > 800m 2 or for 50 or more car parking spaces .

A class 1 bypass interceptor could be considered for this proposal.

However, Suds design usually avoids the use oil separators, and other sumps which are a wildlife hazard, often ineffective and expensive to maintain, in favour of more suitable, nature-based solutions. (i.e Bio-retention areas), (The SUDs manual)

6.3.3 Recommended Suds Options for Sub-Catchment Areas

Roads – discharge to a dedicated detention basin area via, a silt trap. This bioretention area would be provided with a soil medium in excess of 0.6m in depth, allowing for the provision of vegetation planting. Inlet to the detention basin would be via an underdrain, to a modular crate system, with overflow to the depression basin, which would provide attenuation for 1% AEP storm events, to a maximum of 170mm ponding depth, and freeboard of 300mm. A specialist oil degrading geotextile will be provided within the detention basin build-up. (See section 7.5 – Detention Basin Design)

Some portion of the road will also discharge into tree-pits, measuring 2.5m x 2.5m. 12No tree-pits are proposed, each accommodating a maximum of 110m2 of road surface. A specialist oil degrading geotextile will be provided within the tree pit build-up. (see section 7.6 – Tree-Pit Design)

Both the detention basin and tree pits provide good pollutant removal characteristics, with the inclusion of the specialist oil-degrading geotextile barrier. This would mitigate against any hydrocarbon pollution from the road. (See Appendix C)

The design of any such methods of infiltration should allow a factor of safety for progressive siltation to occur (see 7.4.2).
A minimum of 2.5m of unsaturated sub-soil would exist between the geotextile membrane, and the highest level of groundwater, which exceeds the minimum depth of 1.0m recommended within the SUDs Manual.

Carparks – Permeable paving, incorporating a sub-base stone layer, with a specialist geotextile material, which would prevent hydrocarbons and other pollutants entering the subsoil beneath. Additionally, the substantial depth of unsaturated soil (>5.0m) beneath the permeable paving would provide a substantial filtration system.

Roof areas – generally proposed to discharge to soakaways dispersed around the site. This ‘clean’ water from the roof would contain extremely low levels of pollutants. (see section 6.5.2)

These underground soakaways, allow for useful 'play' areas over, and are very efficient in maximizing available space.

A bioretention area / rain garden is proposed to accommodate storm water flow from the roof of 'Block M'. This bioretention area, for this location, was selected for it's amenity and aesthetic value, at this location, rather than a 'soakaway'.

Footpaths – Footpaths will be included in the 'roads' sub-catchment areas.

6.2 Conveyancing System

Roads and Buildings

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The conveyancing system will be PVCu pipework, laid to suitable gradients, and constructed and bedded in accordance with *BS EN 1295-1:2019 Structural Design of buried pipelines under various conditions of loading. General Requirements.*

This drainage pipework will outlet to respective soakaways or bioretention systems (rain gardens),

Some portion of the road will discharge directly to tree-pits. This will be open-channel flow, and no pipework will be required.

Carparking

A direct discharge of stormwater will apply for carparking areas, directly infiltrating to the ground, via permeable concrete blocks. There will be no drainage pipework servicing carparking areas.

The sizing and gradients of the proposed Storm water pipework is presented in Section 7.7 of this report. (also see Appendix B).

6.5 Storm Water Management

6.5.1 Water Quantity

From Buildings;

Storm water will be collected from the roof, via guttering, with discharge to rainwater down pipes – this above ground drainage to be designed to BS EN 12056-3:2000, *Gravity Drainage Systems Inside Buildings.* The receiving gullies are to be of the bottle type gullies (rather than P-trap Gullies); this facilitates ease of maintenance and provides of an initial removal of silt and organic deposits from the roof area.

Thereafter, the storm water is to be conveyed via 100mm dia PVCu pipes laid to a 1:60 gradient, bedded in suitable pea gravel, for a short run, linked to a larger 150mm dia pipe, via a saddle connection. This main drainage pipe will be connected either to an underground soakaway or a bioretention (rain garden) system, via a silt trap manhole, with a minimum 400mm silt trap base.

From Roads:

Storm water from a portion of the road area, will be conveyed via 'open channel' flow directly to individual tree pits.

The gradients of the road will be such that each tree pit can accommodate up to a maximum of 110m2 of road area.

The stormwater from the remainder, larger portion of the road, is to be conveyed to a detention basin area, at the 'front' of the site (south), via suitably sized PVC drainage pipes.(see Appendix B for flow rates).

Carparking areas

Carparking areas will discharge directly to the ground, via permeable paving, laid over a stone sub-base, with direct infiltration to the ground.

Some carparking areas, will be designed to accommodate storm water run-off from adjacent footpaths.

Interception Infiltration > 5mm for all surfaces

Attenuation for Storm Return Periods - Annual Exceedance Probability (AEP)

The storage volume for all discharge options will be designed to a 1:100 year storm event (1%AEP), prior to direct infiltration.

The conveyance pipework is normally designed to 1:10 year storm event (10%AEP). However, the section diameter of most conveyancing pipework, designed to a 10%AEP can also accommodate a 1:100 year storm event (1%AEP).

Bioretention areas and tree pits are designed to limit the surface ponding to a 150mm depth, over the soil media. An overflow pipe is then connected to an underlain attenuation (stone drainage bed, or geo-cellular system) designed to accommodate a 1:100 year storm event.

The detention basin is designed to be generally 'dry' with surface water ponding occurring in the basin at 1:100 year return periods (1% AEP). The maximum designed depth is 170mm, and a 300mm freeboard also is provided.

The occurrence and depth of designed surface ponding within Bioretention areas (raingardens and tree pits), and the detention basin is a function of the inflow rate into the respective systems, which in turn is dependent on rainfall intensity, sub-catchment area, the time duration of the rainfall, and the storm return period. These are summarized and tabulated in appendix D. The determining calculations are contained with the calculation sheet document, annexed to this report.

6.5.2 Water Quality

The following Pollution hazard indices, replicated from table 26.2 – SUDS manual, is shown below.

BLE 6.2 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
Other roofs (typically commercial/ industrial roofs)	Low	0.3	0.2 (up to 0.8 where there is potential for metals to leach from the roof)	0.05
Individual property driveways, residential car parks, low traffic roads (eg cul de sacs, homezones and general access roads) and non-residential car parking with infrequent change (eg schools, offices) ie < 300 traffic movements/day	Low	0.5	0.4	0.4
Commercial yard and delivery areas, non-residential car parking with frequent change (eg hospitals, retail), all roads except low traffic roads and trunk roads/motorways[1]	Medium	0.7	0.6	0.7
Sites with heavy pollution (eg haulage yards, lorry parks, highly frequented lorry approaches to industrial estates, waste sites), sites where chemicals and fuels (other than domestic fuel oil) are to be delivered, handled, stored, used or manufactured; industrial sites; trunk roads and motorways[1]	High	0.8[2]	0.8[2]	0.9[2]

The following is applicable to this proposed development.

Residential Roofs:

Pollution hazard level: 'very low'
Total Suspended Solids (TSS) = 0.2

Metals = 0.2
Hydrocarbons = 0.05

Access road and carpark and individual property driveways. (+ footpaths)

Pollution hazard level: 'low'
Total Suspended Solids (TSS) = 0.5
Metals = 0.4
Hydrocarbons = 0.4

The pollution hazard level for this proposal is between 'very low' and 'low'

6.5.3 Ground water protection measures:

Roof drainage: Gulley pots to provide for silt entrapment, prior to entering main silt trap manhole. These receiving gullies are to be of the bottle type gullies (rather than P-trap Gullies); this facilitates ease of maintenance and provides of an initial removal of silt and organic deposits from the roof area.

Carpark Areas: Filter medium provided by 'grit' layer under permeable paving. A specialist geotextile is also proposed, with hydrocarbon / oil removal characteristics, equivalent to a class 1 oil interceptor. (appendix C).

Roads : Overall, the carparking /road area exceeds 800m2 in area which provide for more than 50 cars. Therefore, an oil separator would normally be provided. However, as cited in the 'SUDS manual', it is preferred that a natural based solution be used, in place of an oil separator, therefore tree pits and detention basins, have been incorporated into the drainage design, to accommodate stormwater run-off from the road.

Suds mitigation indices for discharges to groundwater* , as per CIRIA 753, (table 26.4 – Suds manual),

TABLE 26.4 Indicative SuDS mitigation indices for discharges to groundwater			
Characteristics of the material overlying the proposed infiltration surface, through which the runoff percolates[1]	TSS	Metals	Hydrocarbons
A layer of dense vegetation underlain by a soil with good contaminant attenuation potential[2] of at least 300 mm in depth[3]	0.6[4]	0.5	0.6
A soil with good contaminant attenuation potential[2] of at least 300 mm in depth[3]	0.4[4]	0.3	0.3
Infiltration trench (where a suitable depth of filtration material is included that provides treatment, ie graded gravel with sufficient smaller particles but not single size coarse aggregate such as 20 mm gravel) underlain by a soil with good contaminant attenuation potential[2] of at least 300 mm in depth[3]	0.4[4]	0.4	0.4
Constructed permeable pavement (where a suitable filtration layer is included that provides treatment, and including a geotextile at the base separating the foundation from the subgrade) underlain by a soil with good contaminant attenuation potential[2] of at least 300 mm in depth[3]	0.7	0.6	0.7
Bioretention underlain by a soil with good contaminant attenuation potential[2] of at least 300 mm in depth[3]	0.8[4]	0.8	0.8
Proprietary treatment systems[5, 6]	These must demonstrate that they can address each of the contaminant types to acceptable levels for inflow concentrations relevant to the contributing drainage area.		

Notes

Mitigation Indices.

Referring to the above table 26.4 Suds Manual, the Mitigation indices for discharges to groundwater are as follows;

A soil with good contaminant attenuation potential at and least 300mm of soil depth.

Mitigation Indices, considering soakaways from roofs

Total Suspended Solids (TSS) = 0.4 > 0.2, therefore OK
Metals = 0.3 > 0.2, therefore Ok
Hydrocarbons = 0.3 > 0.05, therefore OK

Sub-soil provided > 2.5m depth (ie > 300mm required for above mitigation indices).

Mitigation Indices, considering Permeable pavements for carparks

Total Suspended Solids (TSS) = 0.7 > 0.5, Therefore Ok

Metals = 0.6 > 0.4, Therefore OK
Hydrocarbons = 0.7 > 0.4 Therefore, Ok

Sub-soil provided > 5.0m depth (ie > 300mm required for above mitigation indices). Also, 2No layers of specialist geotextile, (Selected Specification type: *Tencate Geoclean aquatextile*) incorporated within the pavement build-up.

<u>Mitigation Indices, considering detention basin area for roads.</u>

The construction build-up of the detention basin, specifically at in flow level, is similar to that of a permeable paving build-up, as cited in the above Suds table 26.4: ie an infiltration layer (200mm stone), including a geotextile material at the base of the subgrade , underlain with a soil with good contaminant attenuation, of at least 300mm in depth.

Total Suspended Solids (TSS) = 0.7 > 0.5, therefore Ok
Metals = 0.6 > 0.4, therefore OK
Hydrocarbons = 0.7 > 0.4 Therefore Ok

Sub-soil provided > 2.5m depth (ie > 300mm required for above mitigation indices). Also, layer of specialist geotextile, (Selected Specification type: *Tencate Geoclean aquatextile*) incorporated around underlain attenuation storage.

<u>Mitigation Indices, considering Tree-pits for roads.</u>
<u>(tree pits being a form of bioretention application)</u>

Total Suspended Solids (TSS) = 0.8 > 0.5, therefore Ok
Metals = 0.8 > 0.4, therefore OK
Hydrocarbons = 0.8 > 0.4 Therefore Ok

Additionally, a specialist geotextile material, (Selected Specification type: *Tencate Geoclean aquatextile*) surrounding the modular crates soakaway is to be provided, to mitigate against pollution. This is a two layer aquatextile materials which traps and biodegrades oil from run-off water.

<u>Note:</u> The above specified geotextile has a maximum residual hydrocarbon content in the percolating water < 1mg/L. (with 2No layers). This is a better performance than a Class 1 oil Separator, (5mg/L – EN858-1:2002)

(see *Tencate Geoclean aquatextile datasheet in appendix C)*

All infiltration methods must have a minimum of 1.0m of unsaturated sub-soil, between the invert of the infiltration base and the aquifer. Actual minimum depth between invert of infiltration base and water table > 2.5m.

Bioretention applications (including rain gardens), tree pits and detention basins have a significant contribution throughout all 4 pillars of Suds (water quality, water quantity, amenity and biodiversity) *(Greening and Nature based Suds for Active Travel Schemes- National Transport Authority)*

The tree pits provide good gross solid and sediment removal, via filtration, and have been designed to accommodate same.

6.6 Operation and Maintenance

Management of Surface Water Infiltration System

All Suds systems, including infiltration systems, require regular maintenance and management, to ensure continuing operation to the required design performance standards.

The following regimes are to be implemented as per recommendations – CIRIA SuDS 2016

Maintenance and Pollution Control

Soakaways (Modular Crate System)

Silt is to be prevented from entering the surface waste-water drainage system by the use of trapped bottle gullies as a first control, and then to a common silt trap manholes as a 2nd control.

It is proposed to use proprietary crates (Aquacell Core – R, or equal approved). These crates provide a 95% void ratio, provision for internal inspection, and are suitable for both landscape and trafficked areas.
These are structural crates, typically with a vertical loading capability of 66.9tonnes / m2 and a lateral loading capability of 12.3 tonnes /m2.

Assuming correct installation, the typical lifespan of these modular crate soakaways is typically between 60 years to 100 years. Ref: Wavin product literature).

The maintenance schedule for the soakaways, is to be as follows,

Maintenance Schedule	Required Action	Frequency
Regular Maintenance	Inspect for sediment and debris in pre-treatment components (silt traps), and within inspection chambers and AJ's Cleaning of gutters and any filters on downpipes	Annually Annually, or as required
Occasional Maintenance	Remove sediment and debris from pre-treatment components.	As required
Remedial Actions	Reconstruct soakaway and/or replace or clean void fill if performance deteriorates or failure occurs Replacement of geotextile	As required As required
Monitoring	Inspect silt traps and note rate of sediment accumulation. Check soakaway to ensure emptying is occurring	monthly in first year then annually, as required Annually

Maintenance responsibility: Management Company and KCC when taken in charge.

Permeable Paving

It is proposed to install interlocking concrete block (CBPP) as the permeable paving. (Tobermore, or equal approved)

Assuming correct installation, these type of Suds methods typically have a life span of between 25 years to 50 years. Tobermore, offer a 25 year structural integrity guarantee on their CBPP products.

The specialist geotextile material (Tencate Aquatextile Geoclean, or equal approved), is designed for long term no-maintenance performance, and has a lifespan in excess of 50 years.

The maintenance schedule for permeable paving is to be as follows,

Maintenance Schedule	Required Action	Frequency
Regular Maintenance	Brushing (Standard cosmetic sweep over whole surface)	Once a year, after leaf fall or reduced frequency as required. Based on site-specific observations of clogging or manufacturers recommendations – attention to particular areas where water runs onto pervious surface from adjacent impervious areas.
Occasional Maintenance	Stabilize and mow contributing and adjacent areas. Removal of weeds or management using glyphosate applied direct to weeds by an applicator rather than spraying	As required - once a year on less frequency used area
Remedial Actions	Remediate any landscaping which through vegetation maintenance or soil slip has	As required

	been raised to within 50mm of the level of the paving. Remedial works to any depressions, rutting and cracked or broken blocks considered detrimental to the structural performance pr a hazard to users, and remedial lost jointing material Rehabilitation of surface and upper substructure by remedial sweeping. Replacement of geotextile	Every 10 to 15 years or as required if infiltration performance is reduced due to significant clogging
Monitoring	Initial Inspection	monthly in first year then annually, as required
	Inspect for evidence of poor operation and/or weed growth - if required, take remedial action Inspect silt accumulation rates and establish appropriate brushing frequencies	Annually
	Monitor inspection chambers	Annually

Maintenance Responsibility: Homeowners for carparking spaces within private curtilage Management Company and KCC when 'taken in charge' for common carparking spaces.

Tree pits

Assuming correct installation, tree pits systems typically have a life span of approx 25 years plus. The maintenance schedule for the tree pits is to be as follows,

Maintenance Schedule	Required Action	Frequency
Regular Maintenance	Remove Litter and debris Manage Other Vegetation and remove nuisance plants Inspect Inlets and outlets	Monthly, or as required
Occasional Maintenance	Check Tree Health and manage tree appropriately Remove all silt build-up from the inlets and surface and replace mulch as necessary Water	Annually, or as required As required, or periods of drought
Remedial Actions	Replace tree / pit if severely damaged / diseased	As required
Monitoring	Inspect silt accumulation rates and establish appropriate removal frequencies	Half yearly

Maintenance Responsibility: Management Company / KCC when 'taken in charge'

Bioretention Systems

The lifespan of a bioretention system is approx 25years to 50 years. The specialist geotextile material (Tencate Aquatextile Geoclean, or equal approved) within the system having a lifespan in excess of 50 years.)

The maintenance schedule is to be as follows,

Maintenance Schedule	Required Action	Frequency
Regular Maintenance	Inspect infiltration surfaces for silting and ponding , record de-watering time of the facility, and assess standing water levels in underdrain to determine maintenance is necessary. Check operation of underdrains by inspection of flows after rain Access plants for disease infection, poor growth, invasive species , and replace as necessary Inspect inlets and outlets for blockage	Quarterly
Occasional Maintenance	Check Tree Health and manage tree appropriately Infill any holes or scour in the filter medium, improve erosion protection if required Remove all silt build-up from the inlets and outlets	Annually, or as required As required, or periods of drought

Remedial Actions	Remove and replace filter medium and vegetation	As required, but likely to be > 20 years
Monitoring	Inspect silt accumulation rates and establish appropriate removal frequencies	Half yearly

Maintenance Responsibility: Management Company / KCC when 'taken in charge'

Detention basin

The lifespan of a Detention system is approx 25years to 50 years. The specialist geotextile material (Tencate Aquatextile Geoclean, or equal approved) within the system having a lifespan in excess of 50 years.

The maintenance schedule is to be as follows,

Maintenance Schedule	Required Action	Frequency
Regular Maintenance	Remove Litter and debris Cut grass /remove weeds Manage other vegetation and remove nuisance plants Inspect Inlets and outlets, check ponding / blockages. Check for silt accumulation	Monthly, or as required

	Inspect vegetation coverage Inspect banksides, structures, pipework	
Occasional Maintenance	Re-seed areas of poor vegetation growth, alter plant types to suit vegetation growth if required Remove all silt build-up from the inlets and outlets	Annually
Remedial Actions	Repair erosion or other damage other damage by re-turfing or re-seeding Re-level uneven surfaces and re-instate design levels Repair inlets / outlets Relevel uneven surfaces and reinstate design levels	As required
Monitoring	Inspect silt accumulation rates and establish appropriate removal frequencies	Half yearly

Maintenance Responsibility: Management Company / KCC when 'taken in charge'

7.0 Stormwater Design

7.1 Calculation Procedure for the Design of Soakaway and Infiltration Methods

(refer to calculation sheet document, annexed to this report)

Software: TEKLA TEDDS version 2020

7.1.1 Hydraulic Flow Design Parameters

The rainfall intensity is taken from the Wallingford Procedure.

The rainfall intensities over various time durations are considered in the calculations.
Rainfall Intensity calculations are provided in the attached calculation sheets.

A minimum of 10 year storm return period is taken for conveyancing of storm water, although general common pipe sizes will cater for a 100 year storm period (see pipe conveyancing section). A 20% climate change factor is considered.

From Rainfall Return Period Data (Met Eireann), for killarney Location (See Calculation Sheets)

M5-60 = 18.9
Ratio r: = 0.21

7.1.2 Calculation Method:

Soakaway sizing to BRE digest 365 – Soakaway Design.

Soil infiltration rates have been determined from on-site testing to BRE365 Soakaway design guidelines (See soil testing infiltration report).

Parameters considered:

100 year storm return period for infiltration components (Soakaways, permeable paving, detention basin, treepits and bioretention system)

The maximum time period for emptying to half volume of all infiltration methods is to be 24hrs

Conveyance pipework is designed to 1:10 year. (although can accommodate 1:100 year events)

20% climate change factor considered. (KCDP and *Greater Dublin Regional Code of Practice for Drainage Works)*

Interception Infiltration taken typically considered as 5mm for all surfaces

However, for run-off calculations, this is not considered for impermeable surfaces, and the Coefficient of Volumetric run-off is taken a 1.0. (Percentage of Impermeable area PIMP, taken as 100%). (Sewers for Adoption 7th Edition)

Designated Drainage Stone: Void ratio (min 30%) (MOT type 3 (clause 805 - no fines).

Proprietary 'crates' or tanks, Void ratio taken as 95% for the purposes of calculation.

7.2 Sub-catchment Areas considered:

See ' Sub-Catchment Areas' cited in Appendix B for a detailed breakdown of all respective areas.

In summary, the following total areas are considered; (A*n allowance has been made for 'urban creep' of 10%)*

Impermeable areas

Buildings			**Actual area**	**Area(10% urban creep)**
Block A		=	515.5m2	**567.05m2**
Block B		=	292.4m2	**321.64m2**
Block C		=	515.5m2	
Block D		=	515.3m2	
Block E		=	311.4m2	
Block F		=	718.5m2	
Block J		=	413.6m2	
	Subtotal	=	2474.3m2	**2721.7m2**
Block G		=	413.9m2	**455.3m2**
Block H		=	509.5m2	
Block K		=	286.1m2	
	Subtotal	=	795.6m2	**875.2m2**
Block L		=	363.7m2	**400.1m2**

Block M	=	657.0m2	**722.7m2**
Total roofs	**=**	**5512.4m2**	**6063.6m2**

Roads, total area	=	3302.4m2
Footpaths	=	2171.8m2
Rear access paths	=	1009.6m2
Bin and/or Bike Stores	=	360m2
Total	**=**	**6843.8m2**

Permeable Areas

Carparking	=	3821.5m2
Green Areas**	=	6162.2m2
Total	**=**	**9983.7m2**

**These areas are considered to be 'grassed' or have permeable coverings, and have natural infiltration given the soil characteristics.

Overall total Site Area = 22339.9m2 (c. 2.23Ha)

7.3 Soakaway Design

It is proposed that the storm water from the roofs, in general, are treated by a series of 6No underground Soakaways, comprising of proprietary modular crates. This roof water has minimal potential pollutants (see pollution section). The exception to this, is the roof outflow from 'Block M', which will be treated by a Bioretention area for ecological and aesthetic purposes.

In summary, the following applies;
(Please see calculation sheet document, and Appendix D)

Refer to drawings for sub-catchment designations.

Block A Soakaway No 1

Design Impermeable area = 567.05m2 (inc 10% Urban Creep)

Required Volume = 32.67m3, actual Volume = 33.86m3

Size of Soakaway = 28m2 (9.0m x av. 3.3m) x 1.2m deep.

Time for soakaway to reduce by half = 5hr 13min 41s < 24hrs therefore Ok

Block B Soakaway No 2

Design Impermeable area = 321.64m2 (inc 10% Urban Creep)

Required Volume = 16.97m3, actual Volume = 18.24m3

Size of Soakaway = 4.0m x 4.0m x 1.2m deep.

Time for soakaway to reduce by half = 4hr 10min 31s < 24hrs therefore Ok

Blocks C, D, E, F and J, Soakaway No 3

Design Impermeable area = 2721.7m2 (inc 10% Urban Creep)

Required Volume = 211.18m3, actual Volume = 223.44m3

Size of Soakaway = 14.0m x 14.0m x 1.2m deep.

Time for soakaway to reduce by half = 14hr 50min 42s < 24hrs therefore Ok

Block G Soakaway No 4

Design Impermeable area = 455.3m2 (inc 10% Urban Creep)

Required Volume = 17.54m3, actual Volume = 22.80m3

Size of Soakaway = 5.0m x 4.0m x 1.2m deep.

Time for soakaway to reduce by half = 1hr 50min 46s < 24hrs therefore Ok

Block H and K Soakaway No 5

Design Impermeable area = 875.2m2 (inc 10% Urban Creep)

Required Volume = 54.21m3, actual Volume = 61.56m3

Size of Soakaway = 12.0m x 4.5m x 1.2m deep.

Time for soakaway to reduce by half = 6hr 28min < 24hrs therefore Ok

Block L Soakaway No 6

Design Impermeable area = 400.1m2 (inc 10% Urban Creep)

Required Volume = 22.56m3, actual Volume = 22.8m3

Size of Soakaway = 5.0m x 4.0m x 1.2m deep.

Time for soakaway to reduce by half = 4hr 56min 2s < 24hrs therefore Ok

Block M

Design Impermeable area = 722.7m2 (inc 10% Urban Creep)

See bioretention section, below.

7.4 Bioretention Design

The proposed 'raingardens' and the 'tree pits' will be considered as Bioretention Suds Design.

It is proposed that the general design of the bioretention systems will be to provide raingardens and tree pits as part of a nature based, 'soft SUDs' solution, to accommodate storm water from the proposed road network.

The first flush volume of rainwater, of contributing Sub-catchment areas, will be accommodated by the raingarden / tree-pit, comprising a designed soil medium, including surface ponding of same up to 150mm depth.

Storm events and rainfall intensities which will exceed the 150mm limiting depth within the bioretention area, will overflow to an underlain attenuation system, constructed either from proprietary modular crates and / or drainage stone, with full infiltration to the sub-soil under. This attenuation volume, combined with the bioretention area, will cater for rainfall intensities of up to 1%AEP, with a time taken to reduce the water volume by half, to less than 24hrs. A 20% climate change factor will be applied to all storm water calculations.

The following is considered;

General Construction of Bioretention area No 1 , Sub-catchment: Block M

Soil medium: 600mm depth (see below)

Proprietary modular crates: 2No layers of 1000mm x 500mm x 400mm depth, void ratio = 0.95 ('Aquacel Crates)

A final outlet drainage pipe, accommodating storm water from the relevant sub catchment, will discharge into the bioretention area. This outlet pipe will be provided with a protective 'grill' with a selected stone surround, to landscape architects specifications, so as to provide erosion protection, within the rain garden areas.

The inflow velocity, from the inlet pipe to the bioretention area is to be low (<1.5m/s for a 1:100 year event). Flow should not 'scour' the biorientation surface and should be uniformly distributed over the full filter media surface. The selection and placement of stone around the inlet pipe will impede flow velocity, and create a 'spread' of water flow.

7.4.1 Bioretention / Tree Pits Soil Medium

The soil medium will be imported, to the specifications and composition of the Landscape architect.

The soil media depth for Bioretention area 1, serving the sub-catchment area of Block M, is to be 600mm depth, and is suitable for planting of suitable vegetation, to landscape architect's specifications.

The soil media depth for Bioretention area 2, serving the sub-catchment area of the partial road, is to be 1000mm depth, and is suitable for planting vegetation, including small trees, to landscape architect's specifications.

The soil media depth for Bioretention 'Tree-pit' units, serving the sub-catchment area of partial road areas up to 110m2 /tree pit, is to be 1400mm depth, with a minimum volume of 8m3, and is suitable for planting small trees (<5m) to landscape architects specifications.

The saturated hydraulic conductivity of the soil medium is to be 300mm/hr – to be checked in-situ using single ring infiltration test method to BS EN ISO 22282-5:2012. (Geotechnical Investigation and testing. Geohydraulic testing – infiltrometer tests).

The porosity of the soil > 30% when tested to BS1377-2-1990 *(Methods of test for soils for Civil Engineering purposes classification tests and determination of geotechnical properties).* This porosity (ie 30%) is referred to in Suds Manual cl 18.9.2 for bioretention filter media.

Void ration, e = n /(1-n) (n = porosity)

Therefore, void ration considered, for the bioretention soil medium = 0.3 (1 – 0.3) = 0.43 = 43%.

A factor of safety is to be applied to the soil medium infiltration rate of 300mm /hr (i.e. 8.333x10^-5m/s). See section 7.4.1.1 below.

7.4.2 Siltation Effects on Infiltration performance.

A build-up of silt, over time, can result in a reduced infiltration capacity of the system, with a potential consequence of the exceedance of the designed attenuation volume. This generally effects plane infiltration systems, which have negligible 'vertical' sides, and a build-up of silt, at the bottom of the base area, may 'clog' the infiltration plane. This may apply to the bioretention areas at the junction between the ponding area and the soil media.

Additionally, where infiltration systems are not provided with pre-treatment for silt removal, then siltation of the system can also occur. This may apply to the tree pits, whereby storm water flow from the road, is directed, via 'open channel flow, to the relevant tree pit.

In order to mitigate against possible siltation, a factor of safety should be applied to the infiltration rate, depending on the size of the area to be drained and the result of a 'consequence of failure', as per Table 25.2, Suds manual, extracted below;

Note; these factors of safety are not applied to 3-dimensional infiltration systems, designed to BRE (1991), (eg soakaways), as the bottom of the base is ignored within the BRE calculation method, and any deposit of silt at the bottom, will have negligible effect.

TABLE 25.2 Suggested factors of safety, F, for use in hydraulic design of infiltration systems (designed using Bettess (1996). Note: not relevant for BRE method)

Size of area to be drained	Consequences of failure		
	No damage or inconvenience	Minor damage to external areas or inconvenience (eg surface water on car parking)	Damage to buildings or structures, or major inconvenience (eg flooding of roads)
< 100 m²	1.5	2	10
100–1000 m²	1.5	3	10
> 1000 m²	1.5	5	10

Factors of safety to be applied to soil infiltration rate (not included for soakaway design to BRE365, as this method assumes base layer already 'silted'

7.4.3 Bioretention Attenuation Calculations
(refer to Appendix D and calculation document)

(see Appendix D and calculation documents annexed to this report)

The infiltration rate of the soil medium is taken as = 300mm/hr

The required storage, for a given storm duration, is given thus;

Storage ponding attenuation volume, S = (V1-V2) x t
(limited to a depth of 150mm)

Where:
V1 = Max Surface Run-off from sub-catchment, dependent on rainfall time duration (L/s)
V2 = Max discharge rate (ie soi. infiltration take as soil infiltration rate = 300mm/hr) (L/s)
t = Storm duration (s)

Rainfall Intensities are considered at various storm durations and varying attenuation storage requirements, at return periods of 1:2 years, 1:10 years and 1:100 years, utilizing a 20% climate change factor.

Attenuation storage components will consist of;

(i) surface water ponding within the Bioretention area, limited to 150mm depth
(ii) Soil medium
(iii) Overflow attenuation crate storage or drainage stone, infiltrating to subsoil

In summary,

Sub-catchment Area considered = 722m2 (including urban creep)
PIMP = 100%

Plan area of bioretention area = 13.3m x 3.0m = 39.9m2 on plan.

Attenuation / storage calculation

The bioretention area is to be designed at a 1:100 storm return event (1% AEP), for a surface flow over a maximum bioretention area of 39.9m2. The surface ponding depth will be limited to 150mm, and an overflow pipe(s) is to be provided for any exceedance of this 150mm maximum depth. Direct infiltration through the soil medium, and either an underlain bed of drainage stone, or modular crate system, through to the subsoil, is proposed. A specialist geotextile material (tencate geoclean aquatextile, or equal approved), will laid under, and around, the underlain attenuation areas, forming 2No layers of the geotextile. These layers (soil medium, and stone or crate system) will provide attention, prior to infiltration.

Overall attenuation / storage

Required storage = 27.22m3 ((1:100year at 2hr duration – Appendix D)

Storage provided;

1. Surface ponding depth = 150mm void ratio = 100%
2. Soil media depth = 600mm, void ratio = 43%

3. Modular Crates = 800mm, void ratio = 95%

Volume of storage within crate layer = 13.3m x 3m x 0.8m x 0.95 = 30.32m3
Volume of storage within soil layer = 13.3m x 3m x 0.6m x 0.43 =10.29m3
Volume of storage from surface ponding = 13.3m x 3.0m x 0.15m = 5.99m3

Total storage provided = 46.60m3 > 27.22m3, therefore OK.

Time taken to discharge to half volume (13.61m3) = 8.42hrs < 24hrs, therefore OK.

Surface ponding Calculation

Infiltration rate of soil media = 8.33 X10^-5 m/s (300mm/hr, to be prescribed)

As this bioretention area is considered to be a 'plane' infiltration system, a factor of safety is applied to the infiltration rate over the plane of the soil medium base.

Referring to section 7.4.1.1 Siltation Effects on Infiltration performance (above);

Factor of safety to be applied = 1.5 (table 25.2 Suds Manual), the drained area is 722m2, and given the location of this rain garden, the consequences of failure is such that no damage or inconvenience would be caused.

Factored Infiltration rate of soil media = (8.33 X10^-5 m/s) / 1.5 = 5.56 X10^-5 m/s

Rainfall intensity, and therefore storm water inflow to the system, is considered at varying intervals from 5min to 24hrs.

The excess volume of water, that cannot be infiltrated via the soil medium, up to a 150mm surface ponding depth, is to be discharged via overflow pipes, to the attenuation modular crates, beneath the soil medium.

Storm return periods and rainfall intensities for Bioretention Area 1 - Block M Summary:

Overall volume of proposed bioretention area, including overflow to modular crate system is satisfactory up to 1%AEP, (1:100 return period), utilizing overflow pipes, when the infiltration rates of the soil medium is insufficient.

No overflow is required for all storm durations up to 50% AEP

Overflow is required for storm durations of at 10%AEP, from 10min to 2hr storm durations

Overflow is required for storm durations of at 1%AEP, at from 5mins to 6hr storm durations

A full analysis is given in Appendix D.

7.5 Detention Basin Design

<u>General Construction of Bioretention area No 2 , Sub-catchment: Partial Rd</u>

Soil medium: 720mm depth
Proprietary modular crates: 2No Layer of 1000mm x 500mm x 400mm depth, void ratio = 0.95 ('Aquacel Crates)
Drainage stone: 200mm cl 803 stone, void ratio = 0.3.
Geotextile: 'Tencate' Geoclean Aquatextile, 2No layers.

Sub-catchment Area considered = 2628m2
PIMP = 100%

Plan area of bioretention area = 12.0m x 12.0m

<u>Attenuation / storage calculation</u>

This dry detention area is to be designed at a 1:100 storm return event (1% AEP), for ponding to occur, limited to 170mm deep, over 144m2, within the detention basin. A freeboard of 300mm is provided within the basin. The inlet pipe is directed to the underground modular crate system, which infiltrates through the 200mm stone base, and through the existing soil. A specialist oil-degrading geotextile material is to be installed under, and around, the stone sub-base at the bottom , and around the vertical sides of the detention basin build-up.

During time of high rainfall intensity or duration, the crates, and soil medium, act as attenuation storage, prior to infiltration (see calculations in Appendix D). Additionally, provision is made for ponding, up to 170mm depth, within the detention basin. at 1% AEP storm durations.

<u>Overall attenuation / Storage</u>

The total storage depth of this raingarden, is as follows;

1. Soil media depth = 720mm, void ratio = 43%
2. Depth of Drainage crates = 0.8m, void ratio = 95%
3. Depth of Drainage stone = 0.2m, void ratio = 30%

Volume of storage within Drainage stone layer = 12m x 12m x 0.2m x 0.3 = 8.64m3
Volume of storage within crate layer = 12m x 12m x 0.8m x 0.95 = 109.44m3
Volume of storage within soil layer = 12m x 12m x 0.72m x 0.43 =44.58m3

Total Storage provided below base of basin = 162.66m3

There is an additional provision of storage as surface water ponding, up to 170mm depth, within the detention basin; additional storage from surface ponding = 12m x 12m x 0.17m = 24.5m3

Considering 1%AEP (1:100 year storm return)

Total Required Volume = 187.2m3 (Storm duration 10 hrs, 1:100 yr return period) , which results in 170mm surface ponding within basin, therefore OK.

Time taken to discharge to half volume (93.6m3) = 15.4hrs < 24hrs, therefore OK.

Surface Ponding Calculation

Infiltration rate of existing soil = 5.88 X10^-5 m/s, as determined on site

As this bioretention area is considered to be a ‘plane’ infiltration system, a factor of safety is applied to the infiltration rate over the plane of the soil medium base.

Referring to section 7.4.1.1 Siltation Effects on Infiltration performance (above);

Factor of safety to be applied = 5.0 (table 25.2 Suds Manual), the drained area is 2628m2, and given the location of this rain garden, the consequences of failure is ‘minor damage to external areas or inconvenience (ie surface water on car parking)

Factored Infiltration rate of soil media = (5.88 X10^-5 m/s) / 5.0 = 1.176 X10^-5 m/s

Total available stormwater ponding attenuation volume within bioretention area, limited to 150mm depth = 12.0m x 12.0m x 0.15m = 21.6m3 .

Storm return periods and rainfall intensities for dry detention Area 2 - (partial rd) :

No ponding occurs in the detention basin at 10%AEP, for any storm duration.

Ponding occurs within the detention basin at 1%AEP, at from 4hr to 10hr storm durations

7.6 Tree Pit Sizing

Tree pits are proposed to provide for a nature based solution to some road areas.

Inlet to the tree pits are via 'open channel' of an inlet kerb from the adjacent road surface. Tree pits are designed in compliance with SUDS manual C753, along with the reference to the guidance document '*Greening and Nature Based Suds for active travel schemes - National Transport Authority (NTA)*', and specifically the recommendations regarding the 'Stockholm System' of Tree-pit Design.

Size of individual tree pit = 2.5m x 2.5m x 2.15m deep. (minimum)

Minimum volume of structural soil, including root bulb, = 2.5mx2.5m x 1.4m deep = 8.75m3

Minium requirement for very small tree planting (trees < 5m) = 8m3 ('Stockholm' tree pits, with structural soil)

Therefore, size of tree pit is adequate for tree health. (refer to Landscape architects Specifications)

Areas Considered

Each tree pit is designed to accommodate a maximum road area of up to 110m2. (see calculations in appendix D)

Attenuation / storage calculations

The total storage depth of the tree pit aspect, is as follows

1. Surface ponding depth = 150mm void ratio = 100%
2. Structural Soil media depth = 1400mm, void ratio = 43%
3. Drainage Stone depth = 600mm, void ratio = 30%

Volume of storage within Drainage stone layer = 2.5m x 2.5m x 0.2m x 0.3 = 0.375m3
Volume of storage within crates layer = 2.5m x 2.5m x 0.4m x 0.95 =2.375m3
Volume of storage within soil media layer = 2.5m x 2.5m x 1.4m x 0.43 =3.76m3
Volume of storage from surface ponding = 2.5m x 2.5m x 0.15m = 0.94m3

Check for 1% AEP (1:100 year storm return)

Total Required Volume = 7.04m3 (Storm duration 6 hr) < Total Volume Provided = 7.45 m3 therefore OK.

Therefore OK.

Surface Ponding Calculation
(see Appendix D and calculation document)

Storm water to flow into the tree pit, and infiltrate to the soil medium, with a 150mm surface ponding capacity, over.

As the bioretention area (ie soil medium) is considered to be a 'plane' infiltration system, a factor of safety is applied to the infiltration rate over the plane of the soil medium base.

Referring to section 7.4.1.1 Siltation Effects on Infiltration performance (above);

Factor of safety to be applied = 3.0 (table 25.2 Suds Manual), the drained area is 110m2, and given the location of this rain garden, the consequences of failure is 'minor damage to external areas or inconvenience (ie surface water on car parking)

Factored Infiltration rate of soil media = (8.33 X10^-5 m/s) / 3.0 = 2.77 X10^-5 m/s

Tree pit base area = 2.5m x 2.5m = 6.25m2

Treepit (bioretention) - summary

Overall volume of proposed tree-pit , including overflow pipe to modular crates and drainage bedding stone is satisfactory up to 1%AEP.

Overflow, to underground crates is required for storm durations of 50%AEP (from 30mins to 4hrs)

Overflow, to underground crates, is required for storm durations of 10%AEP (from 5mins to 10hrs)

Overflow, to underground crates, is required for all storm durations of 1%AEP.

(see Appendix D – Summary of Calculations)

7.7 Permeable Paving Design

Carpark areas are to be designed as permeable paving.

Each general carpark area = 2.5m x 5.0m = 12.5m2

Include for an additional 5m2 (ie 2.0m wide footpath adjacent to a 2.5m wide carparking space), to allow for adjacent footpaths, area = 12.5m2 + 5m2= 17.5 m2

Take 1:100 year storm event, and 20% climate change factor.

Soil infiltration rate = 5.88 x 10^-6 m/s

Porosity of sub-base = 0.3 (ie sand/ gravel)

Attenuation storage required = nil (see Appendix D)

Provided = 17.5m2 x 0.2m x 0.3 = 1.02m3 per space

Permeable Paving Summary

Direct infiltration to the ground. No requirement for attenuation storage due good infiltration rates of soil and porosity of sub-base. Permeable paving mimics greenfield site.

Sub-base to be provided for structural purposes, rather than attenuation requirements, as follows;

(Carparking – light vehicle with occasional heavy vehicle over run)

Assumed CBR = 7% (sandy / gravel)

Block = 60mm
Grit layer = 30mm
Subbase, Type 1 = 200mm

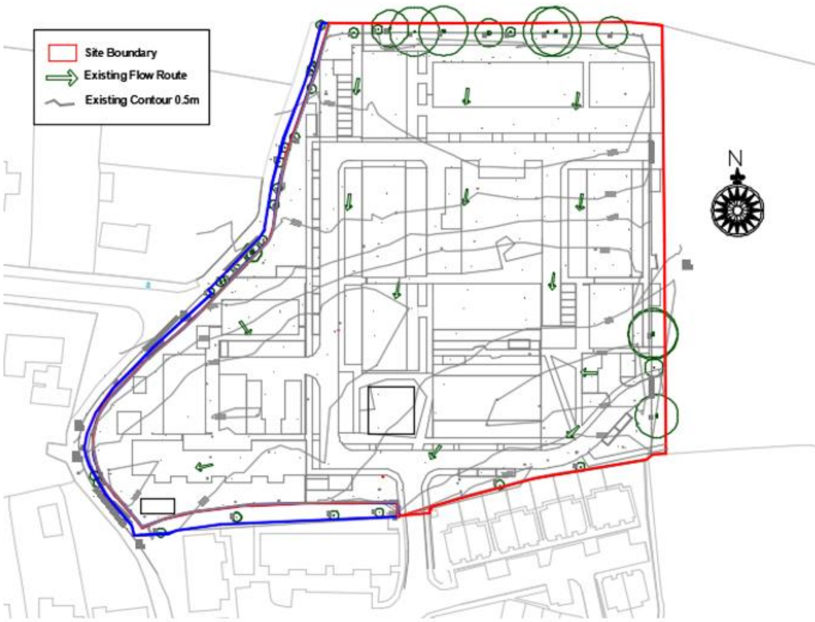
Note: 2No layers of geotextile, (Tencate geoclean, aquatextile, of equal approved)

(see calculation sheet document)

7.8 Flow routes and Greenfield run-off

Whole on-site infiltration is proposed, within the development, with no off-site discharge of storm water, to the public sewer

Existing greenfield run-off rate = 1.9L/s/Ha =1.9 x 2.23Ha = 4.2L/s
(see calculation sheets)
The existing flow routes, relating to contours is shown below;



Existing flow routes

The modified flow routes, post development, while predominantly via road corridors, mimics closely the pre-development flow routes and contour paths.

Various infiltration / suds methods are proposed, capturing various sub-catchments, dispersed around the site, which are generally as follows; (see also Suds Layout drawing)

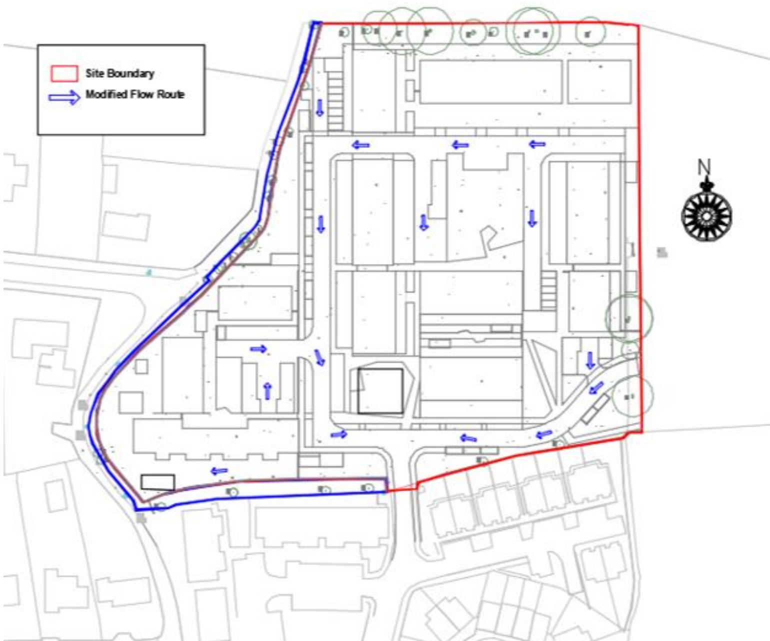
Carparking areas: permeable pavement (Concrete Block Permeable paving)
Roofs: predominately various soakaways dispersed around the site, and a bioretention area
Roads: tree pits and a detention basin area

Generally, the location of soakaways, is proposed under green areas

All Suds methods have been designed with the appropriate factors of Safety, as per SUDs manual, and utilizing a 1:100 year return period and 20% climate change factor.

Any overflow exceedance, which will generally follow the road corridor, is predominately directed to the detention basin area, and the bioretention area, and directed away from buildings.

Given the above infiltration methods proposed, no increase in greenfield run-off rate will occur.



Modified flow routes

7.9 Conveyancing pipework Design

Pipe size and gradient are determined to accommodate the required design flow.
(see calculations in appendices)

PVCu pipes are proposed.

Surface Roughness = 0.6mm (BS 8301).

From Calculations, the maximum rainfall intensity for the conveyance pipe system, is designed to accommodate a minimum 1:10 year storm return period and a 20% climate change factor applied for a 5min storm duration). Additionally, check is made for a 1:100 year storm event, as pipe diameter is unlikely to change significantly, for this higher storm event period.

Take the following maximum rainfall intensities for the following storm events;

1:10 year event (10% AEP): Rainfall intensity = 94.7mm (5min duration)

1:100 year event (1% AEP): Rainfall Intensity = 114.3mm/hr (5min duration)
(see Calculation document)

Flow rates are calculated within each run of pipe, depending on relevant area considered. Flow rate calculations are given in appendices.

The cumulative flow rates are then considered.

The conveyancing pipework is sized accordingly depending on catchment area, rainfall intensity, and gradient.

Storm water drainage flow rates, and final outflow pipe diameter sizes are summarized within Appendix B.

8.0 Foul Water Drainage

The proposed foul water drainage system, is to be connected to the existing public mains system, to the south of the site. A pre-connection application was previously submitted to Uisce Eireann on 16/9/2024 resulting in a Confirmation of Feasibility, which was issued on the 27th March 2025 (Appendix A).

Based on this pre-connection enquiry, Uisce Eireann deemed this proposal "*Feasible, without infrastructure upgrade"*

This pre-connection application was for originally 144No dwellings Units. The actual number of proposed dwelling units was subsequently reduced to 124No. These are comprised of Apartments, duplexes and Town Houses.

Uisce Eireann Reference for this Pre-Connection enquiry is CDS24008514.

Conveyancing of effluent is via PVCu pipes at relevant diameters and gradients, depending on flow loadings, as per Uisce Eireann requirements and Foul Water hydraulic flow calculations.

No storm water run-off will enter the foul water system - all storm water will be treated separately to the foul drainage system, as previously described in this report.

8.1 Foul Water Drainage Design.

The 'population method', used for calculating Dry Weather Flows (DWF) will be used, in accordance with the Uisce Eireann "Code of Practice for Waste Water Infrastructure".

Referring to Section 3.6 – Hydraulic Design For Gravity Sewers of the above Code of Practice (CoP);

The Irish Water requirements for the design of wastewater gravity sewers are set out in Appendix B of this Code of Practice. (Appendix B – Gravity Sewer Design Requirements). However,

"*Works in residential Developments, the sewer capacity criteria for a development are considered to be satisfied, without the need for a full Appendix B design assessment, where the pipe size and gradient requirements for the full potential development population corresponds to those in the Table below for the number of dwellings shown"*

The following table is extracted from the above code of practice, and applicable to this residential development;

Table: Sewer Size/Gradient for Multiple Properties

Number of Dwellings	Pipe Diameter	Minimum Gradient
2 to 9	150mm (or 225mm)	1:60
10 to 20		1:150
21 to 210	225mm	1:200
211 to 250		1:150
251 to 330		1:100
331 – 450	300mm	1:300
451 to 565		1:200
566 to 655		1:150
656 to 830		1:100

The number of proposed dwellings = 124.

For a foul pipe serving between 21No and 210No dwellings, a 225mm dia pipe is permitted, to a minimum gradient of 1:200.
For a foul pipe serving between 10 and 20No dwellings, a 150mm dia pipe is permitted, at a minimum gradient of 1:150.
For a foul pipe serving between 2 and 9No dwellings, a 150mm dia pipe is permitted, at a minimum gradient of 1:60.

Individual dwellings will be first connected to a 100mm dia pipe at 1:40 gradient, before connecting to the main drainage network.

Section 3.6 of the Code Of Practice states that 2.7 persons per dwelling, and a per capita of waste water flow of 150 litres per head per day should be considered within the design calculations, along with a 10% unit consumption allowance (section 3.6.3 and 2.2.4 of CoP).

On this basis the Design occupancy of the proposal = 330 persons.

Dry Weather Flow (DWF)

The Dry Weather Flow, used in the CoP, is defined as "*The average daily flow....during seven consecutive days without rain (excluding a period which includes public of local holidays) following seven days during which rainfall did not exceed 0.25mm on any one day*" - *CIWEM 1993 (Chartered Institute of Water and Environmental Management)*

DWF = (2.7persons x 150L/head/day) x 1.1 = 446 L / dwelling, rounded up to 450 L/dwelling/day

However, a minimum wastewater volume of between 6 times and 2.5 times the dry weather flow (DWF) is required, depending on the size of the Development.

Referring to cl 2.2.5 of the CoP "*Domestic Wastewater Peaking Factors For the design of new or upgraded wastewater networks, the peaking factors applied to domestic wastewater flows (PfDom) are to be in accordance with the Table below".*

Population	Peaking Factor (Pf_{Dom})
0 to 750	6
751 to 1,000	4.5
1001 to 5,000	3.0
5,001 to 10,000	2.5

Number of dwelling units = 124 < 750. Therefore, the Peaking Factor multiplier for this proposed development is 6.

DWF = (124 x 450) / (24x60x60) = 0.65L/s.

6DWF = 3.81 L/s

The overall wastewater generated from the proposed development = 450L x 124 units = **55800L (55.80m3)**

However, referring to the Architects schedule of Design Occupancy, the total number of persons is considered to be more than the average 2.7 persons per dwelling. This will increase the waste water load of the overall drainage system, and for accuracy, it is the following design occupancy that will be used in the drainage calculations.

DWF Litres / day = No persons x 150L x 1.1

DWF for each Building (apartment) block, is shown on the table below;

Building Block	No. of Persons	DWF / day per block L/day	DWF L/s	6DWF L/s	6DWF (m3/s)
Block A	45	7425	0.09	0.52	0.000516
Block B	24	3960	0.05	0.28	0.000275
Block C	45	7425	0.09	0.52	0.000516
Block D	45	7425	0.09	0.52	0.000516
Block E	15	2475	0.03	0.17	0.000172
Block F	35	5775	0.07	0.40	0.000401
Block G	36	5940	0.07	0.41	0.000413
Block H	42	6930	0.08	0.48	0.000481
Block J	36	5940	0.07	0.41	0.000413
Block K	24	3960	0.05	0.28	0.000275
Block L	30	4950	0.06	0.34	0.000344
Block M	50	8250	0.10	0.57	0.000573
Total (L)	**427**	**70455**	**0.82**	**4.89**	**0.004893**

From Architects Design Schedule;

6DWF = 4.89 L/s (at outflow)

The overall wastewater generated from the proposed development= **70455L (70.455m3)**

General Design Requirements

Self-cleansing Velocity

Self-cleansing velocity in the pipe system at least once per day. This varies for pipe sizes with self cleansing velocity of 0.75m/sec for pipes less than 300mm diameter and 0.77m/sec for pipes 375mm and 450mm diameter.

A flow velocity at the design flow (i.e. peak flow) of between the required self cleansing velocity (using 0.75m/sec) and a velocity of 2.0m/s, with an absolute velocity of 2.5m/s as an upper limit should be used.

Roughness Value

The roughness value (ks) for Gravity Sewer design should be chosen to suit the material being proposed and the "long term roughness value" should be chosen.

All drainage pipework will be of PVCu construction. The following roughness factors will apply

Ks = 0.3mm for velocity flow > 1.5m/s
Ks = 0.6mm for velocity flow > 1.0m/s
Ks = 1.5mm for velocity flow 0.76m/s to 1.0m/s and for intermittent flow
(BS 8005 and BS8301)

Gradients and Pipe diameters

Pipe sizes and gradients shall be selected from approved pipe design tables, based on an approved design approach, such as the use of the Colebrook White equation. Alternatively, Pipe sizes and gradients will be checked by calculation.

A service connection with a nominal internal diameter of 100 mm laid to a gradient not flatter than 1:80, where there is at least one WC connected and 1:40 if there is no WC connected.

In general, the following should apply;
Pipes of 100mm diameter should be laid at minimum gradients of between 1:60 and 1:100.
Pipes of 150mm diameter should be laid at a minimum gradient of 1:150.

Pipes of 225mm diameter should have a minimum gradient of 1:200
Pipes of greater diameter should comply with self cleansing and maximum velocity requirements.

Pipe gradients for private side drainage should be constructed in accordance with that indicated above as a minimum, or with Building Regulations requirements.

The maximum allowable gradient for gravity sewers should be chosen so as to achieve a full bore velocity of no greater than 2.5m/s.

Maximum Pipe Gradients to be as follows;

Table: Maximum sewer gradients

Pipe Diameter	Maximum Pipe Gradient
150 mm	1:13
225 mm	1:22
300 mm	1:31

Check on existing sewer connection

The final discharge foul pipe, from the Development is sized at 225mm dia at a 1:100 gradient, which had been sized for a peak flow of 4.89 L/s

This connects on to an existing main sewer pipe, 225mm dia, serving several small housing estates, totalling 200No units.

Dry Weather Flow is existing sewer pipe, $DWF_{existing}$ = (200 x 450) / (24x60x60) = 1.04L/s.

$6DWF_{existing}$ = **6.251 L/s**

Total proposed 6DWF = 6.251 + 4.89 = **11.14L/s**

The 225mm dia pipe at 1:100 gradient, is adequate to accept the proposed discharge rate.

Internal Drainage and Drainage around each block.

The discharge unit method will be used, and the drainage pipe runs around each block will be designed and sized to BS EN 12056-2:2000 – *Gravity Drainage Systems Inside Buildings.*
.

9.0 Mains Water Supply

The proposed water supply system, is to be connected to the existing water mains system, to the south of the site. A pre-connection application was previously submitted to Uisce Eireann on 16/9/2024 , resulting in a Confirmation of Feasibility , which was issued on the 27th March 2025 (Appendix A).

Based on this pre-connection enquiry, Uisce Eireann deemed this proposal "*Feasible, without infrastructure upgrade"*

Calculation of Water Consumption

Average Daily consumption / dwelling unit = 150L/person/day

Design occupancy of overall development = 427 persons x 150L = 64050 L / day

Average Flow rate (for 16hour day) = 64050/(16x60x16) = 1.11L/s

Peak Flow = 5 x 1.11 = 5.55L/s

Internal Pipe dia required = 150mm (section 3.5.15)

Subject to Agreement, an 150mm diameter water connection is proposed, reducing to 100mm diameter branches within the development site. The proposed water main will be will be connected to the existing watermain within the main access road to the development . Adequate valves, hydrants, scour valves or washout hydrants, meters, ducts, tapping locations, Water Main and service pipes, Boundary Boxes, etc will be incorporated into the development, all to Uisce Eireann standard specifications. (Water Supply and Water Infrastructure Standard Details). Water distribution supply to houses, duplex, and apartments to be sized to suit respective uses / building type.

9.1 Fire Flow Requirements

5No Fire Hydrants are proposed, around the site.

Minimum Flow Coefficient = 92.
Equivalent outlet = 2000L/min at 170kPa = 33.3L/s (*BS750:2012 Specification for underground fire hydrants and surface box frames and covers, cl 10.2).*

Minimum internal diameter for Fire Hydrants = 100mm.

Fire hydrants are to be between 6m and 46m from any proposed buildings, to comply with Building Regulations Technical Guidance Document Part B (fire Safety), and installed in accordance with the Uisce Eireann “Code of Practice for Water Infrastructure”.

10.0 Caveats

This Engineering assessment and drainage design report is intended for the aforementioned proposal only, on behalf of Wrightwood Development Ltd and their representatives, and no other external third party without permission.

Teicniuil Priory Consulting Engineers Ltd is obliged to exercise reasonable skill care and diligence in the performance of the services as required and shall not be liable except to the extent that it has failed to exercise reasonable skill, care and diligence and this report shall be read and construed accordingly. No individual is personally liable in connection with the preparation of this report. By receiving this report and acting on it, the client or any other person accepts that no individual is personally liable whether in contract, tort, for breach of statutory duty or otherwise Teicniuil Priory Consulting Engineers Ltd has used reasonable endeavours to provide information that is correct and accurate.

This report remains the intellectual property of Teicniuil-Priory Consulting Engineers Ltd.

Signed: ______________ __________________

Matt Clarke
Chartered Building Engineer

Date: ____________18-12-2025______________________

16/5/2025

Revisions

22/8/2025 (increased to 124No dwelling units, from 122no units)

16-12-2025 (minor amendment to roof / road areas)

References:

Code of Practice for Wastewater Infrastructure - Uisce Eireann
Code of Practice for Water Infrastructure - Uisce Eireann
TGD Part H (Drainage and Waste Disposal)
BSEN 12056-2:2000 Gravity Drainage Systems Inside Buildings
BSEN752-1-4:2008 Drain and Sewer Systems Outside Buildings.
BS EN 1295-1:2019 Structural Design of buried pipelines under various conditions of loading. General Requirements.
BSEN295-3 2012
BS EN-7:2013
BS8582:2013 Code of Practice for Surface Water Management for Development Sites
The SUDS manual (CIRIA 753 revised 2016)
Greater Dublin Regional Code of Practice for Drainage Works.
Joint Defra/EA Flood and Coastal Erosion Risk Management R+D Program, Technical Report
EA Document – Rainfall Management for Development
Civil Engineering Specification for the Water Industry 7th Edition
BRE Digest 365, Soakaway Design 2016
Civil Engineering Specification for the Water Industry 7th Edition
Sewers for Adoption 7th Edition
BS EN 7533-13:2009,pavements constructed with clay, natural stone, or concrete pavers,: Part 13 Guide for the Design of Permeable Pavements Constructed with concrete paving blocks
And flags, natural stone slabs, and setts and clay pavers.
BS 8301 _ Code of Practice for Building Drainage (withdrawn), superseded *by BS EN 752-4:1998 Drain* and sewer systems outside buildings. Hydraulic design and environmental considerations
BS EN 7533-13:2009,pavements constructed with clay, natural stone, or concrete pavers,: Part 13 Guide for the Design of Permeable Pavements Constructed with concrete paving blocks
And flags, natural stone slabs, and setts and clay pavers.
BS750:2012 Specification for underground fire hydrants and surface box frames and covers
Sustainable Residential Development in Urban Areas (2009 DoEHLG)
Kerry County Council Development Plan 2022 to 2028

END

Appendix A

CONFIRMATION OF FEASIBILITY

Jillian O'Neill

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Uisce Éireann
PO Box 448
South City
Delivery Office
Cork City

www.water.ie

27 March 2025

Our Ref: CDS24008514 Pre-Connection Enquiry
Ardshanavooley, Park Road, Killarney, Kerry

Dear Applicant/Agent,

We have completed the review of the Pre-Connection Enquiry.

Uisce Éireann has reviewed the pre-connection enquiry in relation to a Water & Wastewater connection for a Housing Development of 144 unit(s) at Ardshanavooley, Park road, Killarney, Kerry, (the **Development)**.

Based upon the details provided we can advise the following regarding connecting to the networks;

- **Water Connection** - Feasible without infrastructure upgrade by Uisce Éireann
- **Wastewater Connection** - Feasible without infrastructure upgrade by Uisce Éireann

This letter does not constitute an offer, in whole or in part, to provide a connection to any Uisce Éireann infrastructure. Before the Development can be connected to our network(s) you must submit a connection application and be granted and sign a connection agreement with Uisce Éireann.

As the network capacity changes constantly, this review is only valid at the time of its completion. As soon as planning permission has been granted for the to any Uisce Eireann infrastructure. Before the Development can be connected to our network(s) you must submit a connection application and be granted and sign a connection agreement with Uisce Éireann.

As the network capacity changes constantly, this review is only valid at the time of its completion. As soon as planning permission has been granted for the

Development, a completed connection application should be submitted. The connection application is available at www.water.ie/connections/get-connected/

Where can you find more information?

- **Section A** - What is important to know?

This letter is issued to provide information about the current feasibility of the proposed connection(s) to Uisce Éireann's network(s). This is not a connection offer and capacity in Uisce Éireann's network(s) may only be secured by entering into a connection agreement with Uisce Éireann.

For any further information, visit www.water.ie/connections, email newconnections@water.ie or contact 1800 278 278.

Yours sincerely,

Dermot Phelan
Connections Delivery Manager

Appendix B

Conveyancing Pipework - Outlet Flow to SUDs component.

General Parameters

PVCu Pipework surface roughness = 0.6mm

Maximum Rainfall Intensity (5min duration) Considered.

1 to 2 year return period	=	62.4	mm/hr
1 to 10 year return period	=	94.7	mm/hr
1 to 100 year return period	=	114.3	mm/hr

Block	area	Outflow		Pipe gradient	min pipe dia (final Outflow)		outflow to Suds Component	
	(m2)	10% AEP (L/s)	1% AEP (L/S		10% AEP (mm)	1% AEP (mm)		
Block A	515.5	15	22.8	1/150	200	200	soakaway No 1	
Block B	292.4	8.0	12.1	1/150	150	150	soakaway No 2	
Block c	515.5	15.0	22.8	1/150	200	200	soakaway No 3	
Block D	515.3	15.0	22.8	1/150	200	200	soakaway No 3	
Block E	311.4	9.1	13.9	1/150	150	150	soakaway No 3	
Block F	718.5	20.9	31.8	1/150	200	225	soakaway No 3	
Block G	413.9	12.0	18.3	1/150	200	200	soakaway No 4	
Block H	509.5	14.4	22.0	1/150	200	200	soakaway No 5	
Block J	413.6	12.0	18.3	1/150	200	200	soakaway No 3	
Block K	286.1	8.0	12.3	1/150	150	150	soakaway No 5	
Block L	363.7	9.9	15.1	1/150	150	150	soakaway No 6	
Block M	657	18.4	28.1	1/150	200	200	Bioretention area 1	
Partial Road	2628	45.7	69.6	1/150	300	300	Dry Detention area 2	
cumulative Blocks j, C +D	1444.4	41.9	63.9	1/150	300	300	soakaway No 3	
cumulative Blocks E and F	1029.9	30	45.7	1/150	300	300	soakaway No 3	
Road into Tree pits	110 per pit	3.3	5	1/100	150	150	tree pit	

Notes

General Conveyancing pipework generally designed to 1:10 year return period. However, almost all pipe sizes at 1:10year return, can accommodate a 1:100 year return design period.

Appendix C

TENCATE

GeoClean®

OIL-BIODEGRADING AQUATEXTILE

Technical data sheet

TenCate GeoClean®			Origin	Crystal	Pure
Oil fixation and water treatment efficiency (1)					
Chronic and diffuse oil (2)					
Oil fixation rate		%	> 99	> 99	> 99
Residual Hydrocarbon Content (TPH) into water after percolating through the structure with one or two aquatextile levels	1 level	mg/l	< 2	< 2	< 2
	2 levels	mg/l	< 1	< 1	< 1
Localized oil spill (in case of traffic accident) (2)					
Oil fixation rate		%	> 99	> 99	> 99
Maximum fixation capacity of the structure with 1 or 2 two levels of aquatextile	1 level	l/m²	> 0,2	> 0,3	> 0,4
	2 levels	l/m²	> 0,5	> 1	> 2
Active oil biodegradation (2)					
Biodegredation potential (3)			+	++	++++
Optimal biodegradation speed		ml/m²/year	120	120	120
Biodegradation rate compared to an average diffuse oil load from a car park			> x 10	> x 10	> x 10
Water permeability					
Water permeability normal to the plane under a water head of 5 cm		mm/s	> 10	> 10	> 10

Other characteristics

Material	Inert polymer material
Structure	Bicolour two-layer aquatextile made of continuous oleophilic filaments
Active top blue layer	Releases a natural growth activator for the biodegrading microorganisms
Disposal	After use, when the oil is fully biodegraded, the aquatextile can be considered as an inert construction material.

Packaging

	Origin	Crystal	Pure
Rolls	3m x 80m 6m x 80m	3m x 60m 6m x 60m	3m x 40m 6m x 40m

(1) The tests were carried out on pavement systems supplied with engine oil
(2) The test procedure will be communicated upon request
(3) The quantity of biodegradable hydrocarbons depends on the maximum oil fixation capacity.

Attention: the value given are indicative and correspond to average of results obtained in our laboratories and external testing institutes. The above values are those in force on the date of publication of this data sheet and are subject to change at any time. Please check that you have the latest edition of the technical data sheet.

For more information on projects, installation of the aquatextile and the savings, please contact us:

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AQUATEXTILE

Technical textile dedicated to the decontamination of runoff water.

It manages the quality of the rainwater throughout its infiltration into the ground

ACTIVE OIL-BIODEGRADING AQUATEXTILE

Fixes hydrocarbons including PAHs and boosts systematically their biodegradation

TENCATE AQUAVIA

Appendix D
Summarized Hydraulic Calculations

Hydraulic Calculations for Bioretention Area

Sub-Catchment Considered		**:**	**Build / Roof for Block M**			
SuDs Component			Bioretention Area / raingarden			
Size of Suds Componen t	Bioretention Area 1	=	13.3m x 3m on plan	150mm surface ponding 600mm soil medium 800mm Modular Crates		
	overflow storage	=	13.3mx3mx0.8m			
Surface water run-off area		=	722m2	(inc. 10% Urban Creep)		
PIMP		=	100%			
Return period		=	2 years, 10 years and 100 years			
Climate Change factor		=	20%			
<u>Infiltration rate of soils;</u>						
Imported soil media,		=	300 mm/hr	(8.33x10^-5 m/s)	x 13.3m x 3.0m	
Factor of safety		=	1.5	(table 25.2 Suds Manual)		
factored Infiltration rate (outflow) of soil media		=	5.56x10^-5 m/s	=	2.22	L/s
sub-soil infiltration rate		=	5.88x 10^-5 m/s, factored = 5.88x10^-5 / 1.5 = 3.92x10^-5 m/s			
(existing)		=	1.56L/s (factored)			
max depth of surface ponding		=	150mm (ie design maximum permitted)			
surface ponding storage, Vt		=	0.15 x 10m x 4m	=	6	m3

1 to 2 year return period

Storm water duration (t)	**Rainfall Intensity** (i) **(mm/hr)**	**Max Surface run-off** (V1) **(L/s)**	**max outflow through soil (factored) (V2) (L/s)**	**rainfall depth (2 year return period) (d) (mm)**	**Storage required depth (Vs) (m3)**	**available ponding storage (150mm) (Vt) (m3)**	**Depth of ponding in bio-retention (mm)**	**comment**
5 mins	62.4	12.5	2.22	5.2	3.08	< 5.99	77	no overflow
10 mins	46.2	9.3	2.22	7.7	4.25	<5.99	106	no overflow
15 mins	38.9	7.8	2.22	9.7	5.02	<5.99	126	no overflow

30 mins	26.6	5.3	2.22	13.3	5.54	<5.99	139	no overflow
1hr	18.5	3.7	2.22	18.5	5.33	<5.99	133	no overflow
2hr	12.5	2.5	2.22	25	2.02	<5.99	50	no overflow
4hr	8.4	1.7	2.22	33.7	Nil	<5.99	Nil	no ponding
6hr	7.1	1.4	2.22	42.6	Nil	<5.99	Nil	no ponding
10hr	5.1	1.0	2.22	51	Nil	<5.99	Nil	no ponding
24hr	3	0.6	2.22	71.3	Nil	<5.99	Nil	no ponding

Notes:

where depth of surface ponding exceeds 150mm, overflow is directed to an overflow attenuation system. No Overflow occurs

Critical Storm Duration for surface ponding = 30mins

1 to 10 year return period								
Storm water duration (t)	Rainfall Intensity (i) **(mm/hr)**	Max Surface run-off (V1) **(L/s)**	max outflow through soil (factored) (V2) **(L/s)**	rainfall depth (10 year return period) (d) **(mm)**	Storage required depth (Vs) **(m3)**	available ponding storage (150mm) (Vt) **(m3)**	Depth of ponding in bio-retention **(mm)**	comment
5 mins	94.7	19	2.22	7.9	5.03	< 5.99	126	no overflow
10 mins	71.3	14.3	2.22	11.9	7.25	>5.99	181	overflow
15 mins	60.2	12.1	2.22	15.1	8.89	>5.99	222	overflow
30 mins	41.1	8.2	2.22	20.5	10.76	>5.99	269	overflow
1hr	28.1	5.6	2.22	28.1	12.17	>5.99	304	overflow
2hr	18.4	3.7	2.22	36.8	10.66	>5.99	266	overflow
4hr	11.9	2.4	2.22	47.8	2.59	<5.99	64.8	no overflow

6hr	9.8	2	2.22	58.6	Nil	<5.99	Nil	no ponding
10hr	6.9	1.4	2.22	68.9	Nil	<5.99	Nil	no ponding
24hr	3.9	0.8	2.22	92.9	Nil	Nil	Nil	no ponding

Notes:
where depth of surface ponding exceeds 150mm, overflow is directed to an overflow attenuation system
Overflow requirements at 10mins to 2hr storm durations
Critical Storm Duration : 1hr

1 to 100 year return period

Storm water duration (t)	Rainfall Intensity (i) **(mm/hr)**	Max Surface run-off (V1) **(L/s)**	max outflow through soil (V2) **(L/s)**	rainfall depth (100 year return period) (d) **(mm)**	Storage required depth (Vs) **(m3)**	available ponding storage (150mm) (Vt) **(m3)**	Depth of ponding in bio-retention **(mm)**	comment
5 mins	114.3	28.9	2.22	12	8.00	>5.99	200	overflow
10 mins	111.4	22.3	2.22	18.6	12.05	>5.99	301	overflow
15 mins	95.3	19.1	2.22	23.8	15.19	>5.99	380	overflow
30 mins	66.3	13.3	2.22	33.2	19.94	>5.99	499	overflow
1hr	45.8	9.2	2.22	45.8	25.13	>5.99	628	overflow
2hr	29.7	6	2.22	59.4	27.22	>5.99	680	overflow
4hr	19	3.8	2.22	75.8	22.75	>5.99	569	overflow
6hr	15.1	3	2.22	90.7	16.85	>5.99	421	overflow
10hr	10.4	2.1	2.22	103.7	Nil	<5.99	Nil	no ponding
24hr	5.5	1.1	2.22	131.7	Nil	<5.99	Nil	no ponding

Notes:
where depth of surface ponding exceeds 150mm, overflow is directed to an overflow attenuation system
Overflow requirements at 5mins to 6 hr storm durations
Critical Storm Duration : 2hr

time taken for emptying to half volume (13.61m3) = 8.42hrs < 24hrs therefore OK

Hydraulic Calculations for tree-pit areas

Sub-Catchment Considered		**:**	**Road (110m2 of road is considered for 1No Tree pit)**		
SuDs Component			**Tree pits**		
				build-up;	
Size	treepit	=	2.5m x 2.5m on plan	150mm surface ponding	
of			x 2.15m deep (min)	1400mm structural soil	
Suds				400mm modular crates	
Component	overflow storage	=	600mm	200mm drainage stone	
Surface water run-off area		=	110m2		
PIMP		=	100%		
Return period		=	10 years and 100 years		
Climate Change factor		=	20%		
-					
Infiltration rate of soils;					
Imported soil media,		=	300 mm/hr	(8.33x10^-5 m/s)	x 2.5m x 2.5m
Factor of safety		=	3.0	(table 25.2 Suds Manual)	
factored Infiltration rate (outflow) of soil media		=	2.78 x 10^-5m/s	0.174	L/s
surface ponding storage, Vt		=	0.15 x 2.5m x 2.5m		0.94m3

1 to 100 year return period

Storm water duration (t)	Rainfall Intensity (100 year return (i) **(mm/hr)**	Max Surface run-off 100 year (V1) **(L/s)**	max outflow through soil (V2) **(L/s)**	rainfall depth (100 year return period) (d) **(mm)**	Storage Required (Vs) **(m3)**	available storage within drainage (Vt) **(m3)**	Depth of ponding in tree-pit **(mm)**	comment
5 mins	114.3	4.4	0.17	0.7	1.27	>0.94	203	overflow
10 mins	111.4	3.4	0.17	18.6	1.94	>0.94	310	overflow
15 mins	95.3	2.9	0.17	23.8	2.45	>0.94	393	overflow
30 mins	66.3	2.0	0.17	33.2	3.29	>0.94	526	overflow

1hr	45.8	1.4	0.17	45.8	4.41	>0.94	706	overflow
2hr	29.7	0.9	0.17	59.4	6.48	>0.94	1037	overflow
4hr	19	0.6	0.17	75.8	6.13	>0.94	982	overflow
6hr	15.1	0.5	0.17	90.7	7.04	>0.94	1127	overflow
10hr	10.4	0.3	0.17	103.7	4.54	>0.94	726	overflow
24hr	5.5	0.2	0.17	131.7	2.25	>0.94	359	overflow

Notes:
where depth of surface ponding exceeds 150mm, overflow is directed to an overflow attenuation system
Overflow requirements at all storm durations
Critical Storm Duration : 6hr

1 to 10 year return period

Storm water duration (t)	Rainfall Intensity (10 year return (i) **(mm/hr)**	Max Surface run-off 10 year (V1) **(L/s)**	max outflow through soil (V2) **(L/s)**	rainfall depth (10 year return period) (d) **(mm)**	Storage Required (Vs) **(m3)**	available storage within drainage (Vt) **(m3)**	Depth of ponding in tree-pit **(mm)**	comment
5 mins	94.7	2.9	0.17	7.9	0.82	<0.94	131	overflow
10 mins	71.3	2.2	0.17	11.9	1.22	>0.94	194	overflow
15 mins	60.2	1.8	0.17	15.1	1.46	>0.94	234	overflow
30 mins	41.1	1.3	0.17	20.5	2.03	>0.94	324	overflow
1hr	28.1	0.9	0.17	28.1	2.61	>0.94	418	overflow
2hr	18.4	0.6	0.17	36.8	3.07	<0.94	491	overflow
4hr	11.9	0.4	0.17	47.8	3.25	<0.94	521	overflow
6hr	9.8	0.3	0.17	58.6	2.72	<0.94	435	overflow
10hr	6.9	0.2	0.17	68.9	0.94	<0.94	150	overflow
24hr	3.9	0.1	0.17	92.9	Nil	<0.94	Nil	No ponding

Notes:
where depth of surface ponding exceeds 150mm, overflow is directed to an overflow attenuation system
Overflow requirements at all storm durations, except 24hr duration
Critical Storm Duration : 4hr

1 to 2 year return period								
Storm water duration (t)	Rainfall Intensity (10 year return (i)	Max Surface run-off 10 year (V1)	max outflow through soil (V2)	rainfall depth (2 year return period) (d)	Storage Required (Vs)	available storage within drainage (Vt)	Depth of ponding in tree-pit	comment
	(mm/hr)	(L/s)	(L/s)	(mm)	(m3)	(m3)	(mm)	
5 mins	62.4	1.9	0.17	5.2	0.52	<0.94	83	no overflow
10 mins	46.2	1.4	0.17	7.7	0.74	>0.94	118	no overflow
15 mins	38.9	1.2	0.17	9.7	0.92	<0.94	148	no overflow
30 mins	26.6	0.8	0.17	13.3	1.13	>0.94	180	overflow
1hr	18.5	0.6	0.17	18.5	1.53	>0.94	245	overflow
2hr	12.5	0.4	0.17	25	1.63	<0.94	260	overflow
4hr	8.4	0.3	0.17	33.7	1.81	<0.94	290	overflow
6hr	7.1	0.2	0.17	42.6	0.56	<0.94	90	no overflow
10hr	5.1	0.2	0.17	51	0.94	<0.94	150	no overflow
24hr	3	0.1	0.17	71.3	Nil	<0.94	Nil	No ponding

Notes:
where depth of surface ponding exceeds 150mm, overflow is directed to an overflow attenuation system
Overflow requirements between 30mins and 4hr storm durations
Critical Storm Duration : 4hr

Hydraulic Calculations for Partial Road area

Sub-Catchment Considered		**:**	**Partial Rd**		
SuDs Component		Dry detention area			
					build-up
Size of Suds Component	Detention area Area	=	12m x 12m on plan		allowance for ponding <170mm
					720mm soil medium
					400mm attenuation crates
	overflow storage	=	12mx12mx0.4m	crates	200mm drainage stone
			12mx12mx0.2m	stone	
Surface water run-off area		=	2628	(road and footpaths)	
PIMP		=	100%		
Return period		=	10 years	and 100years	
Climate Change factor		=	20%		
Infiltration rate of soil medium , i		=	300 mm/hr	(8.33x10^-5 m/s) x 12.0m x 12.0m	
Factor of safety		=	5	(table 25.2 Suds Manual)	
factored Infiltration rate (outflow) of soil media		=	1.67x10^-5 m/s	= 2.4 L/s	
sub-soil infiltration rate		=	5.88x 10^-5 m/s		
Factor of safety		=	5	(table 25.2 Suds Manual)	
factored Infiltration rate (outflow) of existing soil base		=	1.176x10^-5m/s	= 1.69 L/s	

1 to 10 year return period

Storm water duration (t)	Rainfall Intensity (i) **(mm/hr)**	Max Surface run-off (V1) **(L/s)**	max outflow through soil (V2) **(L/s)**	rainfall depth (10 year return period) (d) **(mm)**	Storage required **(m3)**	available storage **(m3)**	Depth of water level over formation level **(mm)**	comment
5 mins	94.7	69.1	1.69	7.9	20.223	162.66	140	no ponding

10 mins	71.3	52	1.69	11.9	30.186	162.66	210	no ponding
15 mins	60.2	44	1.69	15.1	38.079	162.66	264	no ponding
30 mins	41.1	30	1.69	20.5	50.958	162.66	354	no ponding
1hr	28.1	20.5	1.69	28.1	67.716	162.66	470	no ponding
2hr	18.4	13.4	1.69	36.8	84.312	162.66	585.5	no ponding
4hr	11.9	8.7	1.69	47.8	100.944	162.66	701	no ponding
6hr	9.8	7.1	1.69	58.6	116.856	162.66	811.5	no ponding
10hr	6.9	5	1.69	68.9	119.16	162.66	827.5	no ponding
24hr	3.9	2.8	1.69	92.9	95.904	162.66	666	no ponding

Notes:

No Ponding occurs at any storm duration.

Critical Storm Duration : 10hrs

1 to 100 year return period

Storm water duration (t)	Rainfall Intensity (i) **(mm/hr)**	Max Surface run-off (V1) **(L/s)**	max outflow through soil (V2) **(L/s)**	rainfall depth (100 year return period) (d) **(mm)**	Storage required **(m3)**	available storage (Vt) **(m3)**	Depth of water level over formation level **(mm)**	comment
5 mins	144.3	105.3	1.69	12	30.87	162.66	214	no ponding
10 mins	111.4	81.3	1.69	18.6	47.34	162.66	329	no ponding
15 mins	95.3	69.6	1.69	23.8	60.48	162.66	420	no ponding
30 mins	66.3	48.4	1.69	33.2	82.8	162.66	575	no ponding
1hr	45.8	33.4	1.69	45.8	111.6	162.66	775	no ponding

2hr	29.7	21.7	1.69	59.4	138.96	162.66	965	no ponding
4hr	19	13.8	1.69	75.8	164.16	162.66	1140	10mm
6hr	15.1	11	1.69	90.7	185.76	162.66	1290	160mm
10hr	10.4	7.6	1.69	103.7	187.2	162.66	1300	170mm
24hr	5.5	4	1.69	131.7	138.24	162.66	960	no ponding

Notes:

Critical Storm Duration : 10hr

time taken for emptying to half volume (93.6m3) = 15.4hrs < 24hrs therefore OK