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1.0. INTRODUCTION

1.1 Background

Fingal County Council is in the process of preparing a Local Area Plan for Portmarnock South for the period 2013-2019 which will provide a 6 year statutory framework which will inform and guide development.

Waterman Moylan have been appointed by Fingal County Council to carry out a Sustainable Drainage Systems (SuDS) strategy to inform the Local Area Plan.

It is the responsibility of each applicant for planning permission to provide appropriate SuDS as part of their proposed development for which permission is sought. This report sets out a strategy for the preparation of SuDS design for each phase of development within the LAP lands and for the lands as a whole.

1.2. Objective of this Report

This report is a working briefing document intended to assemble the background information, objectives, and criteria for the development of a SuDS strategy for the Portmarnock South LAP lands.

2. Portmarnock South Site Location and Description / Characteristics.

2.1 Site Location

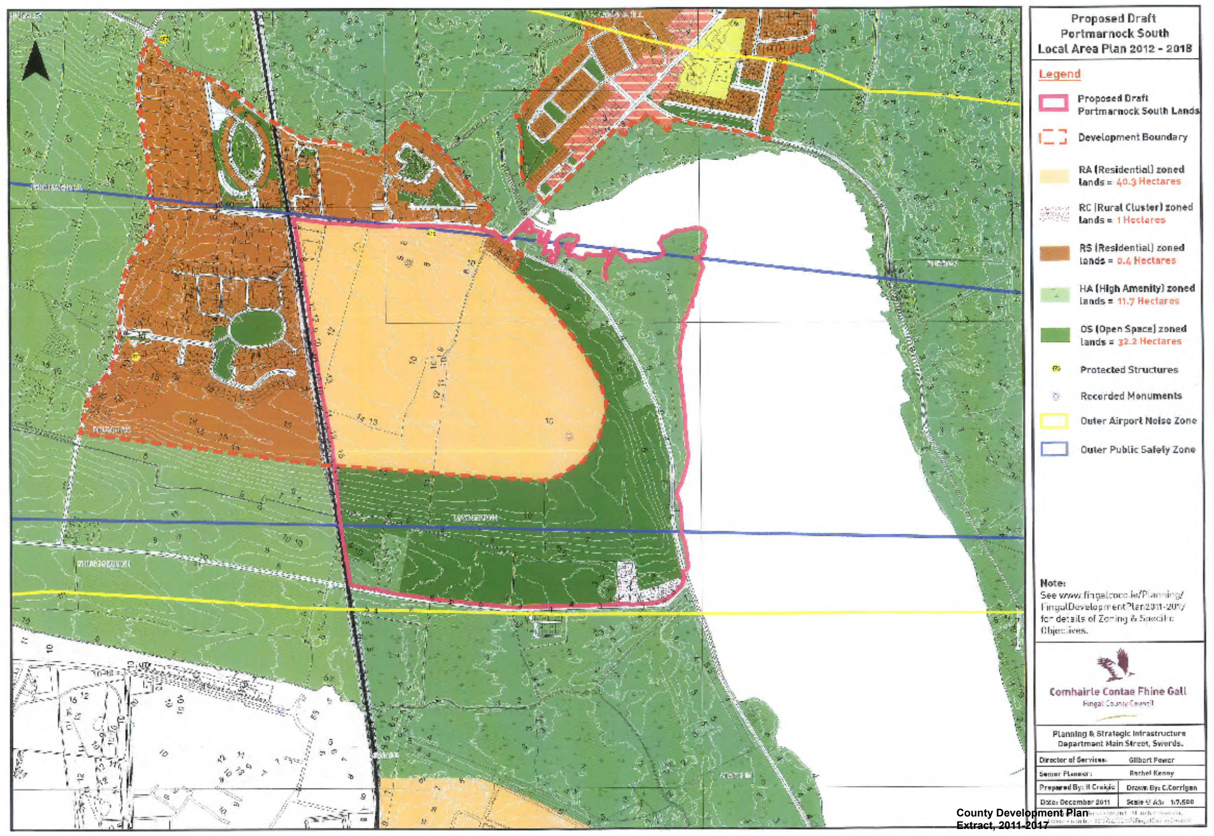
The Portmarnock South Local Area Plan (LAP) lands are located within southeast Fingal. The lands are bound to the east by the coast road and Baldoyle Estuary, to the west by the Dublin – Belfast Railway line, to the north by Station Road and to the south by Mayne Road and the Baldoyle – Stapolin LAP lands.

2.2. Site Description

The LAP lands total approximately 85.6 Ha. of which approximately 40.3 Ha. are zoned Objective RA to *provide for new residential communities in accordance with approved local area plan*, approximately 32.2 Ha zoned Objective OS to *preserve and provide for open space and recreational amenities,* 11.7 Ha zoned Objective HA to *protect and enhance high amenity areas,* 1 Ha zoned RC to *provide for small scale infill development serving local needs while maintaining the rural nature of the cluster* and 0.4 Ha zoned Objective RS to *provide for residential development and protect and improve residential amenity*.

The site currently comprises of agricultural lands and natural coastal landscape. The site is dissected by an open drainage ditch which rises from the centre of the lands and drains north-eastwards before discharging to a culvert in the northeast of the lands west of the five existing cottages.

Figure 2.0 LAP Zoned Lands



2.3. Topography

The overall site falls from a level of approximately 15m OD Malin half way along the west boundary to approximately 4m OD Malin along the Coast Road boundary to the east.

2.4. Hydrology

The northwest quarter of the LAP lands drain towards the existing open drainage ditch that bisects the site. This open ditch drains to the west of the five number cottages in the northeast of the land. From here it is culverted northwards under Station Road to the Sluice Stream before crossing the coast road where it discharges to the estuary.

The lands to the east of the open ditch drain eastwards towards the coast road. There is no water course evident along the east of the site that connects to the sea.

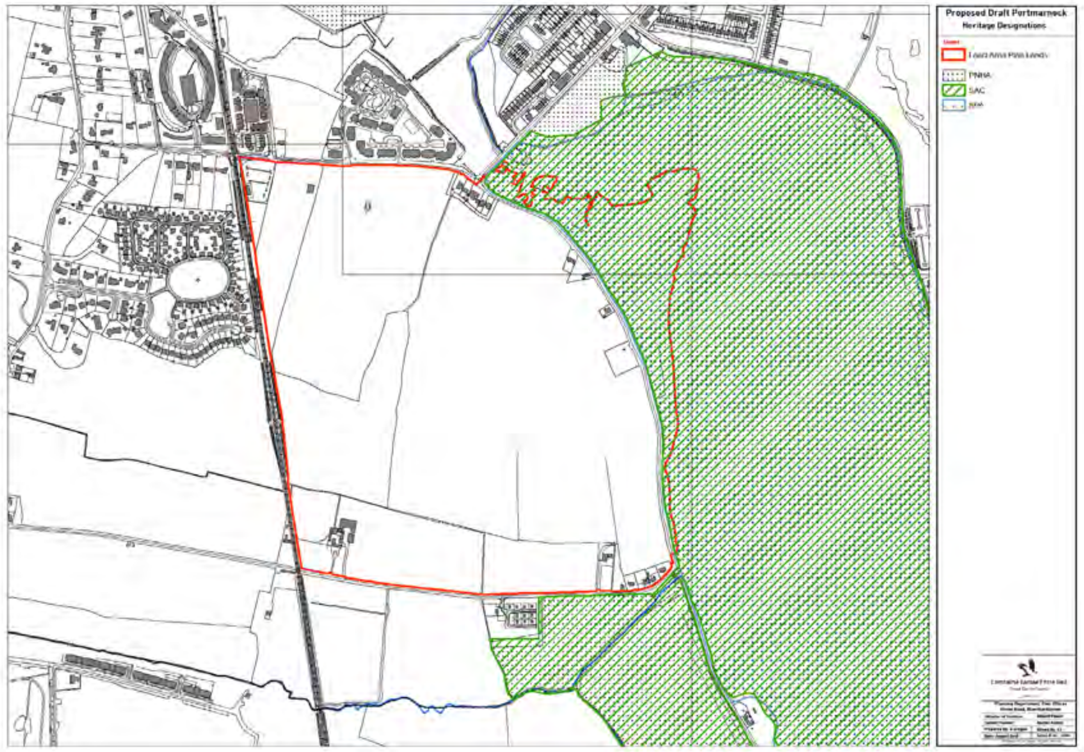
The southern half of the LAP lands drains to the southeast where the River Mayne discharges to the Baldoyle Estuary.

2.5. Baldoyle Estuary

The Baldoyle Estuary is a Natura 2000 site and is designated as a Special Protection Area and a Candidate Special Area of Conservation under the Birds and Habitats Directives respectively. It is also a Ramsar site recognised as being a wetland of international importance, while nationally it is a proposed National Heritage

Area. It is also a statutory Nature Reserve. The extent of the SAC is shown below on Figure 2.1.

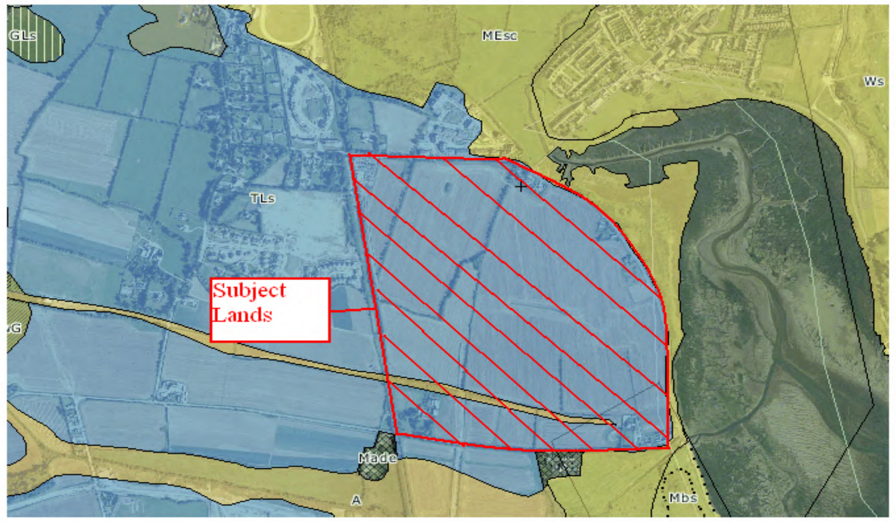
Figure 2.1: Extent of SAC



2.6. Geology and Geotechnical

From the Geological Survey of Ireland the quaternary soil type for this area is described as Limestone Tills (TLs), as shown below in Figure 2.2.

Figure 2.2: GSI Geological Survey of Ireland – Quaternary



The GDSDS Flood Study Report maps indicate a Soil Index of Soil Type 2 for the subject site. This suggests that the soil has a high rain acceptance potential (infiltration potential). This indicates that infiltration techniques may be suitable on the subject site. Site investigations should be carried out to confirm the soil type for each site.

As shown on Figure 2.3 below, the Geological Survey of Ireland shows the site lying on a locally important aquifer with bedrock which is moderately productive only in local zones.

Figure 2.3: GSI Geological Survey of Ireland – National Draft Gravel Aquifer Map

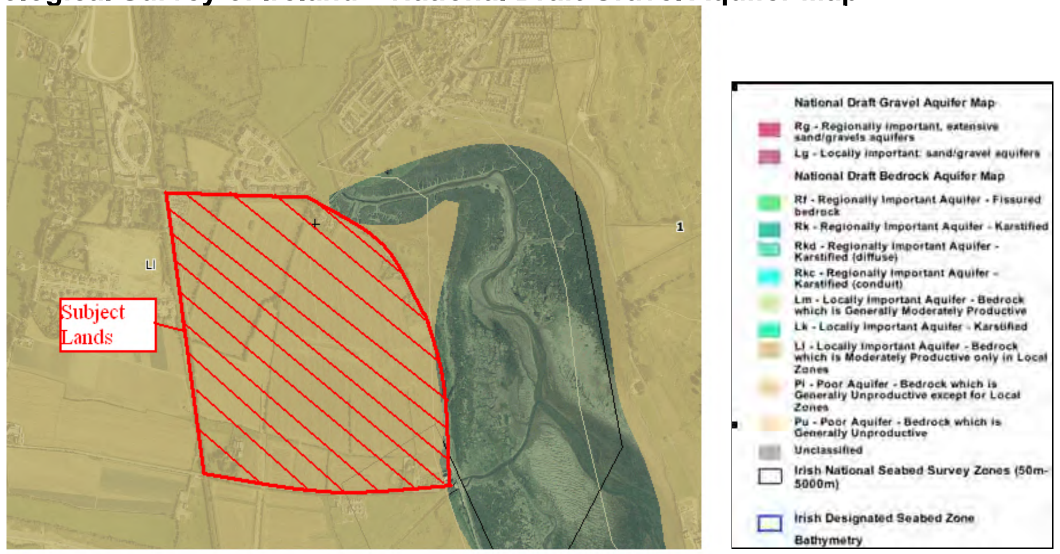
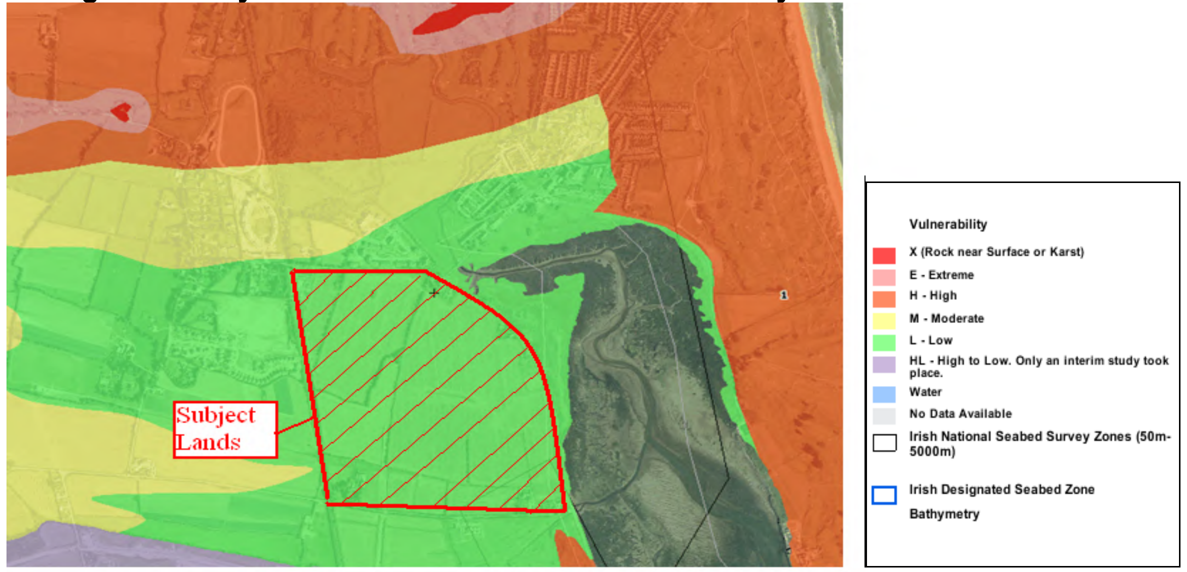


Figure 2.4 below indicates the aquifer has a low vulnerability.

Figure 2.4: GSI Geological Survey of Ireland – Groundwater Vulnerability



3. The Development

3.1. Existing Development

There are currently five dwellings together in the northeast of the site with another three dwellings further south along the Coast Road.

Another 5 dwellings front onto Mayne Road in the southeast of the site, with Mayne Lodge also fronting onto Mayne Road in the southwest corner of the lands.

Portmarnock Train Station and car park is located in the northwest of the LAP lands.

3.2. Proposed Development

As part of the 2013-2019 LAP it is proposed to provide a residential development comprising up to 1,200 dwellings on the Plan lands.

It is proposed to implement SuDS devices throughout the proposed development. A Surface Water Management Train approach is to be adopted in the design of the proposed surface water drainage regime for the subject lands by utilising suitable SuDS mechanisms in providing Source, Site and Regional Control.

4 SuDS Strategy Outline

4.1. General

This briefing document sets out the criteria used to define and assess the SuDS strategy proposed for the Portmarnock South LAP. This report describes the criteria on which the design and construction of any storm water related works within the LAP lands shall be based. These criteria shall include the requirements of the following:-

- This SuDS Strategy
- The (GDSDS) 'Greater Dublin Strategic Drainage Study'
- The CIRIA 'Sustainable Urban Drainage Systems' Manual C697

Details of general strategies, SuDS constructions and selection criteria are contained in Appendix A of this report.

4.2. Water Quality

Given the sensitivity of the receiving environment for storm water runoff from the LAP lands it is considered that the criterion for Water Quality is the overriding factor in the design of the storm water system.

All development within the LAP area must implement a SuDS Strategy which addresses water quality, water quantity, amenity and diversity. A SuDS strategy should adopt a Surface Water Management Train approach in the design of the proposed surface water drainage regime by utilising suitable SuDS mechanisms in providing Source, Site and Regional Control.

Interception storage is also to be provided on site where possible; however, the nature of the soil may not facilitate infiltration.

Treatment storage is required on site and should be provided within SuDS devices such as filter drains, bio-retention areas, tree pits and permanent water bodies such as wet lands.

4.3. Storm Water Attenuation & Tidal Effects

The site is located adjacent to the tidal estuary and as there is no downstream development before outfalling to the Irish Sea, it is not required to provide full attenuation for the 100 year return storm as per the requirements in Section 6.6, Volume 2, of the GDSDS.

The principle issue therefore is the quality of water discharge from the LAP lands and not the quantity of water discharged to the estuary.

However, as the proposed outfall sewer will be subject to influence from high tides due to tide locking it is necessary to consider storing surface water during high tides when surface water discharge rates will be limited at the outfall to the sea.

The outfall will be tide locked during extreme high tide events and for this assessment it is assumed that the tide lock may be closed for a period of up to 6 hours. It was agreed to review the storage of surface water flows from the subject site during these times.

The worse case scenario occurs when the outfall is tide locked and a fluvial event occurs. If a significant storm event occurred during this tide lock the outfall is surcharged and a conservative approach is used by assuming there is no outfall rate from the site during the entire 6 hours of tide lock. Table 4.0 below gives the volumes of water discharged from the site based on several rainfall events with return periods up to the 100 year event:

Table 4.0: 6 Hour Attenuation during Tide Lock

Return Period	Rainfall (mm)	Attenuation Volume Required
1 Year	20mm	3,970m³
5 Year	28mm	5,650m³
10 Year	32mm	6,480m³
30 Year	41mm	8,110m³
50 Year	45mm	8,970m³
100 Year	52mm	10,270m³

The storage volumes were obtained by simulation using Micro Drainage with the following design parameters:-

- Zoned Lands = 40 Hectares
- Hardstanding Area = 20 Hectares (50%)
- Soil Type = 2 (based on a high infiltration potential indicated by the GDSDS Flood Report maps, as outlined in Section 2.6)
- Climate Change = 15%
- Discharge Rate = 0 l/s (due to tide lock)
- M5-60 value = 15.70 (automatically given by the storage design software based on the chosen site location)
- 'r' ratio = 0.3 (automatically given by the storage design software based on the chosen site location)

It should be noted that the volumes assessed above do not take into account the runoff that would have occurred during the six hour storm event if the lands were undeveloped and therefore do not represent the amount of attenuation required if the site were to be considered to be subject to the GDSDS attenuation criteria. The volumes have been estimated to establish the order of magnitude of the volumes of water that may be generated during a six hour tide lock condition.

In order to address the water quality issues it is proposed to provide a wetland area capable of retaining up to 3,000m³ of permanent water to provide for treatment storage (first 15mm of rainfall on hardstanding areas). These wetlands will provide treatment storage and removal of pollutants from surface water.

The wetlands should have a permanent water volume of approximately 3000m³.

In addition the volume of treatment storage required and the retention time within the wetlands will determine the shape and size of the proposed wetlands. Storm events should be allowed to overflow directly into the sea.

The preferred location for regional wetlands is generally at the lower end of the site and immediately upstream of the outfall / receiving waters. For the subject site the optimum location for the wetlands would be along the eastern boundary, southeast of the existing five houses and / or along the northern boundary, west of the existing five houses. The impact of the wetlands on the landscape and ecology will be minimal.

Refer to the SuDS Strategy General Arrangement drawing in Appendix C for the proposed locations of the wetlands.

4.4. Public Open Space

Open spaces within the lands zoned for development should be utilised to provide surface water treatment and storage during flood events with zoned open space lands being used as a secondary option or for regional control.

4.5. Outfalls

It is proposed to provide an outfall for the site southeast of the existing five cottages in the northeast of the lands. This outfall will be culverted under the Coast Road before discharging to the estuary. This outfall should be designed to discharge surface water for the entire site.

A second outfall can be located west of the existing five cottages. An existing 375mm diameter culvert exists at this location. The culvert currently drains the open drainage ditch that dissects the lands. The head of the culvert is located at the rear of the west most cottage of the five houses.

The culvert drains northwards under Station Road to the existing stream on the north side of Station Road. The stream traverses around The Links development before crossing the coast road where it discharges to the estuary. This outfall may need to be upgraded and / or realigned to accommodate development in the north and northwest of the zoned lands. The existing levels along the south and south east of the site are not appropriate to drain to this outfall.

All development within the LAP area must be designed to tie-in with the proposed outfall arrangements set out in this SuDS Strategy. All outfalls must be protected against surcharging from the sea.

5. Portmarnock South SuDS SELECTION

5.1 General

As part of the detail design of the drainage systems within the Portmarnock South LAP lands, all surface water design and construction works shall be based on the SuDS Strategy, incorporating an integrated approach to the management of runoff from each phase of development, neighbourhood and the LAP lands as a whole.

The selection of suitable and appropriate SuDS techniques to be incorporated into the SuDS train for any specific site depends on the objectives and on the site conditions.

The type and location of SuDS to be selected should be based on the following:

- Land Use Characteristics
- Site Characteristics
- Catchment Characteristics
- Quantity and Quality Performance Requirements
- Amenity and Environmental Requirements
- Economics and Maintenance

5.2 Land Use Characteristics

Land use characteristics introduce additional constraints on the suitability of the SuDS constructions. These characteristics are discussed in Section 3 of this report.

In summary the key land use characteristics that impact on the selection of SuDS are:-

- Urban development
- Car parks
- Roads
- Housing
- Parks
- High amenity zoned lands

5.3 Site Characteristics

Site characteristics are critical in determining which SuDS techniques are best suited to drain and treat the surface water drainage. The characteristics of the Portmarnock South LAP lands are discussed in Section 2 of this report.

In summary the key characteristics that impact on the selection of SuDS are:-

- Green field site
- Medium to steep site with an average gradient of 1:35
- Coastal and tidal outfall
- Sensitive outfall estuary
- Bird feeding areas
- Space Required

5.4 Catchment Characteristics

As outlined in section 2.4 the northwest quarter of the LAP lands drain towards the existing ditch that bisects the site. This ditch is culverted to the stream on the north of Station Road before discharging to the Baldoyle Estuary.

The lands to the east of this ditch drains towards the coast road. There is no water course evident along the east of the site that connects to the sea. The southern half of the LAP lands (south of the lands zoned for development) drains to the south east where the River Mayne discharges to the Baldoyle Estuary.

As outlined in section 2.5 the Baldoyle estuary is a sensitive and protected area. Surface water discharging to the estuary should have a high level of SuDS implemented resulting in a low risk of pollution.

In summary the key catchment characteristics that impact on the selection of SuDS are:-

- Drainage Sub Catchment Area
- Medium to steep site with an average gradient of 1:35
- Discharge to Sensitive Area (Baldoyle Estuary)

5.5 Quantity and Quality Performance Requirements

In summary the key quantity and quality characteristics that impact on the selection of SuDS are:-

- Pollutant removal
- Water quality
- Groundwater recharge
- Flow rate control

5.6 Amenity and Environmental Considerations

The provision of open spaces and pocket parks within the development lands will lend itself to areas for SuDS features. Permanent water features such as local retention ponds may be utilised to provide upstream attenuation and treatment storage.

The perimeter or low lying planted areas should be utilised to provide bioretention systems that convey and treat the surface water.

The open space zoned lands could also be utilised as a wetlands area, providing treatment storage for the surface water runoff from the developed lands. Careful consideration must be given to the location and impact of any enhanced wetlands area.

In summary the key amenity and environmental characteristics that impact on the selection of SuDS are:-

- Safety
- Pond premium
- Aesthetics
- Wildlife habitat and ecology
- Community acceptance

5.7 Economics and Maintenance

Maintenance must be considered when selecting SuDS techniques. Some SuDS techniques are less onerous than others with regard to frequency of maintenance, equipment required, accessibility and personnel responsible.

For SuDS at source control the responsibility generally lies with the private house / block owner. Maintenance should not require heavy machinery and should be easily accessible.

Maintenance of SuDS at site control varies but is generally carried out by the Local Authority. Ideally this should involve occasional maintenance that is easily accessible and may require light machinery.

Maintenance of regional SuDS control may require heavy machinery but should be designed to require remedial works infrequently. Again these are generally under the charge of the Local Authority.

For regional controls such as ponds and wetlands a Management, Monitoring and Maintenance regime will need to be prepared and operated. Designers should also assess all foreseeable risks during construction and subsequent maintenance. The design must minimise these risks by avoidance, reduction and mitigation.

In summary the key economic and maintenance characteristics that impact on the selection of SuDS are:-

- Life span
- Initial cost
- Maintenance cost
- Maintenance expertise

5.8 Selection of SuDS Controls

Various SuDS techniques have been rated under each of the above headings outlined in Sections 5.2 to 5.7. These tables are given in Appendix B. The SuDS techniques rated in each of the tables in Appendix B are listed below:

Source Control
- Pervious Pavements
- Bioretention Areas
- Infiltration Trenches
- Filtration Trenches
- Water Butts
- Rainwater Harvesting Systems

Site Controls
- Pervious Pavements
- Bioretention Areas
- Infiltration Trenches
- Filtration Trenches
- Swales
- Petrol Interceptor

Regional Controls
- Wet Ponds
- Stormwater Wetlands

A total score has been given to each SuDS technique produced by combining the score from each of the tables in Appendix B. A matrix table is provided below in Table 5.1 which combines the total score for each SuDS technique.

Table 5.1: Decision Criteria for Selecting SUDS Techniques

Technique	Land Use Characteristics	Site Characteristics	Catchment Characteristics	Quality and Quantity Performance	Amenity and Environment	Economics and Maintenance	Total
Pervious pavements	21	14	15	12	12	8	**82**
Bioretention	23	15	18	15	16	9	**96**
Filter drains	23	18	14	13	12	8	**88**
Grassed filter strips	22	11	13	10	15	9	**80**
Swales	20	11	11	10	13	10	**75**
Infiltration devices	16	10	15	12	10	7	**70**
Infiltration basin	14	9	14	12	11	7	**67**
Extended detention basin	22	12	12	8	13	10	**77**
Wet ponds	21	14	15	13	20	9	**92**
Stormwater wetlands	21	14	16	17	22	9	**99**
On-/off line storage	14	14	13	4	9	12	**66**

5.9 Implementation of SuDS

Various SuDS techniques have been rated under each of the above headings outlined in Table 5.1.

Due to the additional requirement of the protection of the Baldoyle Estuary, an integrated sustainable system is recommended as a combination of source controls, site controls and regional controls to ensure a high quality of the water runoff from the developed lands.

<u>Source Control</u>

- Pervious Pavements – In private parking areas and private hardstanding areas.
- Bioretention Areas – Provide in private areas with hardstanding pavements and downpipes draining to these areas. A perforated overflow pipe will be required to discharge to the main public sewer.
- Infiltration Trenches - Provide in rear gardens and private areas with hardstanding pavements and downpipes draining to these areas. Soil type and permeability testing should be carried out to ensure the ground and depth to water table is suitable.
- Filtration Trenches - Provide in rear gardens and private areas with hardstanding pavements and downpipes draining to these areas. A perforated overflow pipe will be required to discharge to the main public sewer.
- Water Butts – Should be provided for houses.
- Rainwater Harvesting Systems – Only appropriate for large apartment blocks and commercial units. Storage may not be available during extreme rainfall events and as such should not be included for treatment storage / attenuation calculations.

The following is an outline strategy of SuDS devises for source control:

Source Control	Roofs / Yards	Driveways / Parking Bays
Pervious Pavements	10%	25%
Bioretention / Landscaped Areas	20%	35%
Infiltration Trench	Only to be used if adequate infiltration and water table level	
Filtration Strips	10%	10%
Water Butts	30%	
Rainwater Harvesting	Only appropriate for large apartment blocks and commercial units	
Direct to SW Network / Site Control	30%	30%

<u>Site Controls</u>

- Pervious Pavements - Should be used for public parking bays and hardstanding areas only if FCC Roads will take them in charge.
- Bioretention Areas / Tree Pits – Bioretention area should be utilised within pocket parks and open spaces. Tree pits should be provided with parking areas and along road side verges. Gullies or open kerbs should drain road runoff to these areas with a perforated overflow pipe discharging back into the main public sewer.
- Infiltration Trenches – Infiltration trenches should be provided within pocket parks and open spaces. Road gullies can also drain to infiltration trenches provided under roadside verges. Soil type and permeability testing should be carried out to ensure the ground and depth to water table is suitable.
- Filtration Trenches – Filtration trenches should be provided within pocket parks and open spaces. Road gullies can also drain to filtration trenches provided under roadside verges.
- Swales – Should be provided where the road reservation has sufficient width to incorporate swales.
- Petrol Interceptor – Runoff from roads and parking areas should pass through a petrol interceptor.
- Infiltration devices are most likely not suitable on site due to the lack of adequate infiltration. Infiltration tests must be carried out to insure the ground is suitable where infiltration devices are proposed.

The following is an outline strategy of SuDS devises for site control:

Site Control	Feeder Roads	Access Roads	Parking Along Roads	Foot & Cycle Paths
Pervious Pavements	Only to be used in public areas where acceptable to Fingal County Council Taking in charge requirements			
Bioretention / Landscaped Areas	30%	30%	30%	80%
Filtration Strips	10%	10%	10%	
Swales	30%	30%	30%	
Direct to Surface Water Network	30%	30%	30%	20%
Petrol Interceptor	80%	80%	80%	
Infiltration Devices	Only to be used if adequate infiltration and water table level			

Regional Controls

- Wet Ponds – Should be provided as a final treatment before discharging to the Baldoyle Estuary. Wet ponds should provide treatment storage and attenuation.
- Stormwater Wetlands – Should be provided as a final treatment before discharging to the Baldoyle Estuary. Wet ponds should provide treatment storage and attenuation.

The following is an outline strategy of SuDS devises for regional control:

Regional Control	Surface Water Network from New Development
Wetlands	100%

As the site is currently a green field site and due to the fact that it will discharge surface water directly to the estuary which is a SAC and sensitive area, it is critical that the risk of polluted discharge water is minimised.

It is proposed that all surface water runoff from the site will pass through at least one SuDS device before discharging to a regional wetlands where final treatment will be take place before outfalling to the estuary.

It is proposed that road runoff and runoff from car parks will pass through two SuDS devices before discharging to the regional wetlands, where possible.

All existing ditches and water courses on site should be utilised to form part of the SuDS train where feasible.

APPENDIX A - SUSTAINABLE URBAN DRAINAGE SYSTEM

A-1 Background to SuDS

Sustainable urban drainage is a concept that incorporates long term environmental and social factors into drainage design. It takes account of both the quantity and quality of runoff as well as the amenity value of surface water in the urban environment.

Appropriately designed, constructed and maintained SUDS are more sustainable than conventional drainage methods because they can mitigate many of the adverse effects on the environment of stormwater runoff. They achieve this through:

- reducing runoff rates, thus reducing the risk of downstream flooding
- reducing the additional runoff volumes and runoff frequencies that tend to be increased as a result of urbanization, and which can exacerbate flood risk and damage receiving water quality
- encouraging natural groundwater recharge (where appropriate) to minimize the impacts on aquifers and river base flows in the receiving catchment
- reducing pollutant concentrations in stormwater, thus protecting the quality of the receiving water body
- acting as a buffer for accidental spills by preventing a direct discharge of high concentrations of contaminants to the receiving water body
- reducing the volume of surface water runoff discharging to combined sewer systems, thus reducing discharges of polluted water to watercourses via CSO spills
- contributing to the enhanced amenity and aesthetic value of developed areas
- providing habitats for wildlife in urban areas and opportunities for biodiversity enhancement.

They do this by:

- Dealing with runoff close to where the rain falls
- Managing potential pollution at its source now and in the future
- Protecting water resources from point pollution (such as accidental spills) and diffuse sources.

A-2 SuDS Management Train

A SuDS strategy should adopt a Surface Water Management Train approach in the design of the proposed surface water drainage regime by utilising suitable SuDS mechanisms in providing Source, Site and Regional Control.

Each section and phase of the development within the LAP lands must demonstrate to the satisfaction of the Local Authority that water quality improvement measures are adequately provided using the approved methods.

The following are examples of SuDS devices for source, site and regional control:

Source Control – control of runoff at or near to its source

- Rainwater Harvesting
- Permeable Paving
- Filter Drains
- Green Roofs
- Bioretention Tree Pits
- Infiltration Trenches

Site Control – management of water in a local area or site

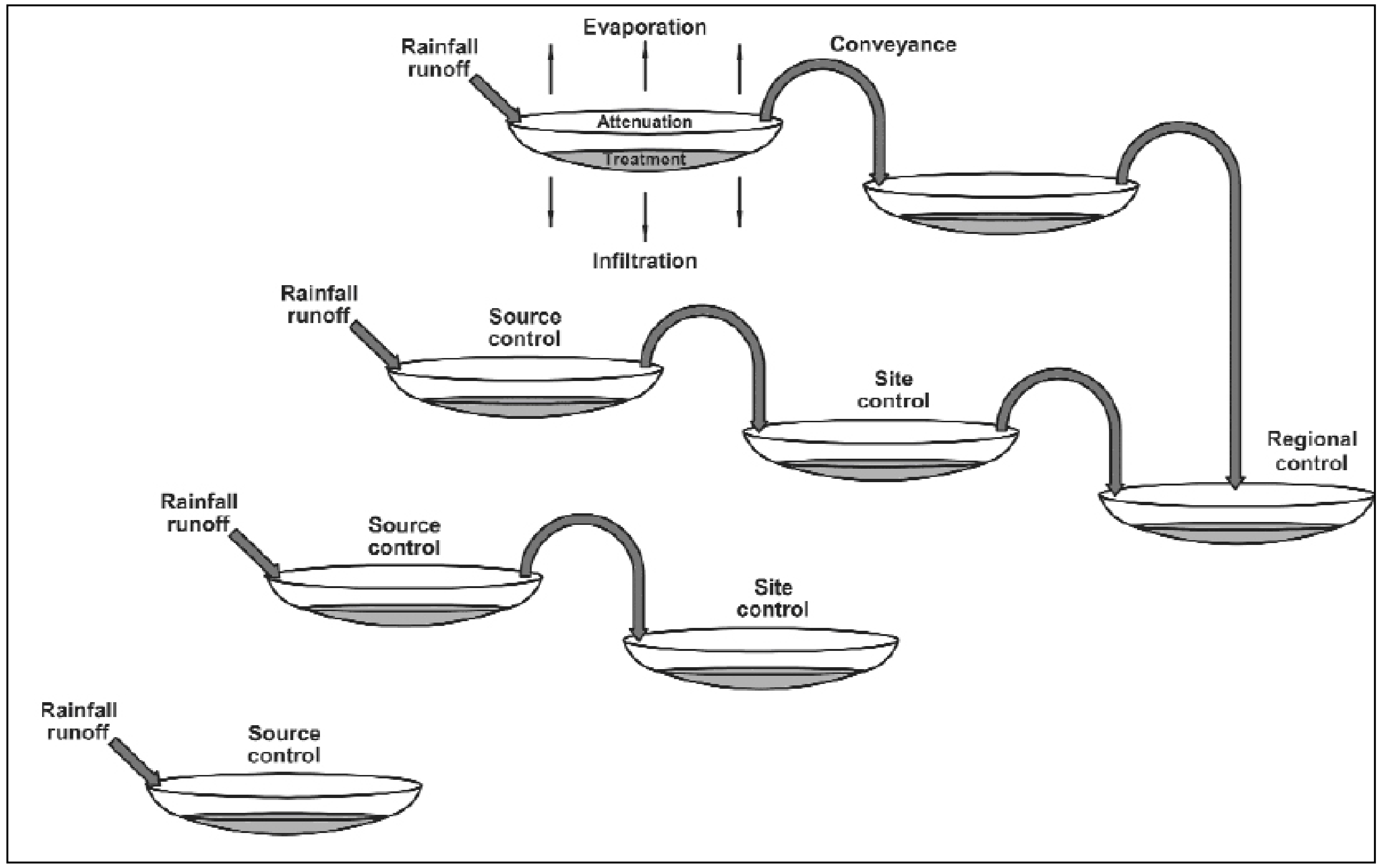
- Permeable Paving
- Filter Drains
- Swales
- Bioretention Tree Pits
- Infiltration Trenches
- Petrol Interceptor

Regional Control – management of runoff from a site or several sites

- Petrol Interceptor
- Retention Pond
- Detention Ponds
- Wetland

As a priority, stormwater should be managed in small, cost-effective landscape features located within small sub-catchments rather than being conveyed to and managed in large systems at the bottom of drainage areas. The SuDS Trains in Figure A.1 below conveys a hierarchy with the higher trains preferred to those further down. This indicates that prevention and control of water at source should always be considered before site or regional controls.

Figure A.1 The SUDS management train



The more SuDS controls the surface water from the development passes through the less risk of pollution to the Mayne River and ultimately to the Baldoyle Estuary. The conveyance of water between SuDS control should be via natural conveyance systems (e.g. swales, filter trenches and bioretention areas) where possible, although pipework and sub-surface proprietary products may be required due to limited space.

The variety of the above options should be considered for the various phases of development on the lands with consideration given to local land use, land take, amenity and maintenance.

A-3 Surface Water Quality Control

There are several processes by which SuDS remove pollutants which include the following:

Precipitation
This process is the most common mechanism for removing soluble metals. Precipitation involves chemical reactions between pollutants and the soil or aggregate that transform dissolved constituents to form a suspension of particles of insoluble precipitates. Metals are precipitated as hydroxides, sulphides, and carbonates depending on which precipitants are present and the pH level. Precipitation can remove most metals (arsenic, cadmium, chromium III, copper, iron, lead, mercury, nickel, zinc) and many anionic species (phosphates, sulphates, fluorides).

Sedimentation
Sedimentation is one of the primary removal mechanisms in SUDS. Most pollution in runoff is attached to sediment particles and therefore removal of sediment results in a significant reduction in pollutant loads. Sedimentation is achieved by reducing flow velocities to a level at which the sediment particles fall out of suspension. Care has to be taken in design to minimise the risk of re-suspension when extreme rainfall events occur.

Filtration and biofiltration
Pollutants that are conveyed in association with sediment may be filtered from percolating waters. This may occur through trapping within the soil or aggregate matrix, on plants or on geotextile layers within the construction.

Adsorption
Adsorption occurs when pollutants attach or bind to the surface of soil or aggregate particles. Eventually the materials onto which pollutants adsorb will become saturated and thus this method of treatment will stop.

Biodegradation
Biodegredation is the biological treatment of pollutants in surface water by using the oxygen within the free-draining materials and the nutrients supplied with the inflows, to degrade organic pollutants such as oils and grease.

Uptake by plants
In ponds and wetlands, uptake by plants is an important removal mechanism for nutrients (phosphorous and nitrogen). Metals can also be removed in this manner (although intermittent maintenance is required to remove the plants otherwise the metals will be returned to the water when the plants die).

Nitrification
Ammonia can be oxidised by bacteria in the ground to form nitrate, which is a highly soluble form of nitrogen. Nitrate is readily used as a nutrient by plants.

The removal mechanism appropriate for each pollutant is presented in Table A.2.

Table A.2 Removal mechanisms for each pollutant category

Pollutant	Removal mechanisms in SUDS
Nutrients Phosphorous, nitrogen	Sedimentation, biodegradation, precipitation, de-nitrification.
Sediments Total suspended solids	Sedimentation, filtration.
Hydrocarbons TPH, PAH, VOC, MTBE	Biodegradation, photolysis, filtration and adsorption.
Metals Lead, copper, cadmium, mercury, zinc, chromium, aluminium	Sedimentation, adsorption, filtration, precipitation, plant uptake.
Pesticides	Biodegradation, adsorption, volatilisation.
Chlorides	Prevention.
Cyanides	Volatilisation, photolysis.
Litter	Trapping, removal during routine maintenance.
Organic matter, BOD	Filtration, sedimentation, biodegradation.

The various SuDS techniques can be used to form part of the management train. Table A.3, extracted from Ciria C697, The SUDS Manual, list various SuDS techniques and categorises them into pre-treatment, conveyance, source, site and regional controls. They are also ranked on their hydraulic and water quality performance potential.

Table A.3 Capability of different SuDS techniques

Technique	Description	Management train suitability						Water quantity				Water quality								Environmental benefits		
		Prevention	Conveyance	Pre-treatment	Source control	Site control	Regional control	Conveyance	Detention	Infiltration	Water harvesting	Sedimentation	Filtration	Adsorption	Biodegradation	Volatilisation	Precipitation	Uptake by plants	Nitrification	Aesthetics	Amenity	Ecology
Water butts, site layout & management	Good housekeeping and good design practices.	◆	⊗		◆			⊗	⊗	◆	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗
Pervious pavements	Allow inflow of rainwater into underlying construction/soil.	◆			◆	⊗			◆	◆	⊗	◆	◆	◆	◆	◆				⊗	⊗	⊗
Filter drain	Linear drains/trenches filled with a permeable material, often with a perforated pipe in the base of the trench.		◆		◆	⊗		◆	◆				◆	◆	◆	◆						
Filter strips	Vegetated strips of gently sloping ground designed to drain water evenly from impermeable areas and filter out silt and other particulates.			◆	◆			⊗	⊗	⊗		◆	◆	◆	◆					⊗	⊗	⊗
Swales	Shallow vegetated channels that conduct and/or retain water (and can permit infiltration when un-lined). The vegetation filters particulates.		◆		◆	◆		◆	◆	⊗		◆	◆	◆	◆			⊗		⊗	⊗	⊗
Ponds	Depressions used for storing and treating water. They have a permanent pool and bankside emergent and aquatic vegetation.					◆	◆		◆	⊗	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
Wetlands	As ponds, but the runoff flows slowly but continuously through aquatic vegetation that attenuates and filters the flow. Shallower than ponds.		⊗			◆	◆	⊗	◆	⊗	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
Detention basin	Dry depressions designed to store water for a specified retention time.					◆	◆		◆			◆	⊗	⊗	◆			⊗		⊗	⊗	⊗
Soakaways	Sub-surface structures that store and dispose of water via infiltration.				◆					◆			◆	◆	◆							
Infiltration trenches	As filter drains, but allowing infiltration through trench base and sides.		⊗		◆	◆		⊗	◆	◆			◆	◆	◆	◆						
Infiltration basins	Depressions that store and dispose of water via infiltration.					◆	◆		◆	◆			◆	◆	◆	◆				⊗	⊗	⊗
Green roofs	Vegetated roofs that reduce runoff volume and rate.	◆		◆	◆				◆				◆	◆	◆	◆	◆	◆	◆	◆	⊗	◆
Bioretention areas	Vegetated areas for collecting and treating water before discharge downstream, or to the ground via infiltration.				◆	◆			◆	◆		◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
Sand filters	Treatment devices using sand beds as filter media.			◆		◆	⊗		◆	⊗			◆	◆	◆	◆	◆					
Silt removal devices	Manhole and/or proprietary devices to remove silt.			◆								◆										
Pipes, subsurface storage	Conduits and their accessories as conveyance measures and/or storage. Water quality can be targeted using sedimentation and filter media.		◆			◆		◆	◆			⊗	⊗									

Key to symbols ◆ High/primary process ⊗ Some opportunities, subject to design

Table 1.7 *Capability of different SUDS techniques*

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SuDS treatment train should be used to manage pollution risks. The recommended number of SuDS devices required for runoff from a development generally depends on where the runoff comes from. The higher the risk of the runoff carrying pollutants the more treatment is required. Table A.4 below is a useful guideline for managing a SuDS treatment train for a residential or mixed use development.

Table A.4 Recommended Number of Treatment Train Components

Receiving water sensitivity → / Runoff catchment characteristic ↓	Low	Medium	High
Roofs only	1	1	1
Residential roads, parking areas, commercial zones	2	2	2
Refuse collection/ industrial areas/ loading bays/lorry parks/highways	3	3	3

A-4 SuDS Controls

The following is a brief outline of the various SuDS techniques which can be used at source, site and regional:

Source Control

1. *Minimise directly connected impervious areas.*
   Provision of rainwater harvesting, rainwater butts, soakaways with overflows, disconnecting roof drains and directing flow to vegetated areas, directing flows from hardstanding areas to stabilized vegetated areas.

2. *Permeable pavement:*
   A permeable hardstanding designed to promote infiltration of surface runoff into a permeable sub-base.

3. *Infiltration trench:*
   A trench, usually filled with permeable granular material, designed to promote infiltration of surface water to the ground.

4. *Green roofs:*
   A roof with vegetation growing on its surface, which contributes to local biodiversity. The vegetated surface provides a degree of retention, attenuation and treatment of rainwater and promotes evapo-transpiration.

5. *Rainwater Harvesting:*
   A system that collects rainwater locally rather than allowing it to pass to the drainage system. This rainwater once harvested can then be treated and be reused for domestic uses other than human consumption such as flushing of toilets, washing machines, garden irrigation.

6. *Bioretention Area / Tree Pit:*
   A planted area or tree pit that filters surface water through engineered filter material before runoff discharging treated surface water through a perforated overflow pipe back into the main drainage system. This can be used in private areas for run off from roofs and paved areas and also from public roads through integrated kerb inlet slots.

Site Control

7. *Swale:*
   A grass channel for stormwater collection with shallow side slopes and gradients to allow ease of maintenance and which is normally dry except during rainfall.

8. *Filter Strip:*
   A gentle uniformly sloping vegetated area designed to drain surface runoff as sheet flow from impermeable surfaces and remove sediment.

9. *Extended detention basin:*
   A vegetated depression, normally dry, constructed to store surface water temporarily during periods of rainfall to attenuate flows and provide some treatment and possibly infiltration.

10. *Infiltration basin:*
    A basin, which is normally dry, that is designed to store and infiltrate surface runoff into the ground.

11. *Existing Ditches:*
    Can be utilised where possible to convey runoff from the development to a proposed attenuation area. The ditch will provide treatment, infiltration and storage and mimic the natural catchment behaviour. The existing ditch system should be retained where possible.

12. *Bioretention:*
    A drainage practice that utilizes landscaping and soils to treat urban stormwater runoff, filtering it through a designed planting soil media and collecting the flow through perforated under-drainage pipework.

Regional Control

13. *Retention pond:*
    A SuDS pond consisting of a significant sized permanent pool of water (up to 4 times the treatment volume for the site) designed to treat surface runoff by detaining the water to provide settling of sediments, and chemical and biological processing as well as provide attenuation. Often used to provide high amenity value

14. *Stormwater wetland:*
A continuously wet area in which the water is shallow enough to enable the growth of bottom-rooted plants. It has a requirement for a continuous base flow to maintain healthy vegetation. Treatment of stormwater can be very effective, but if used for attenuation, consideration needs to be given to the effect of fluctuating water levels on plant life.

Design, details, features and maintenance issues associated with each of these SuDS features are contained in Appendix B of this report.

A-5 Quantity and Quality Performance Requirements

As part of the detail design of the drainage systems within the Portmarnock South LAP, the quantity and quality of the surface water runoff is critical. The quality of surface water runoff is in particularly critical due to the sensitivity of the Baldoyle Estuary.

Table A.5 gives a matrix of the benefits of various SuDS techniques for quality, quantity, community and performance.

Table A.5: Quality, quantity, community and performance matrix - CIRIA C697.

SUDS Group	Technique	Water quality treatment potential					Hydraulic Control				Maintenance	Community acceptability	Cost	Habitat creation potential
		Total suspended solids removal	Heavy metals removal	Nutrient (phosphorous, nitrogen) removal	Bacteria removal (*)	Capacity to treat fine suspended sediments and dissolved pollutants	Runoff volume reduction	Suitability for flow rate control (probability) 0.5 (1/2yr)	Suitability for flow rate control (probability) 0.1 – 0.3 (10/30 yr)	Suitability for flow rate control (probability) 0.01 (100 yr)				
Retention	Retention pond	H	M	M	M	H	L	H	H	H	M	H*	M	H
	Subsurface storage	L	L	L	L	L	L	H	H	H	L	H	M	L
Wetland	Shallow wetland	H	M	H	M	H	L	H	M	L	H	H*	H	H
	Extended detention wetland	H	M	H	M	H	L	H	M	L	H	H*	H	H
	Pond/wetland	H	M	H	M	H	L	H	M	L	H	H*	H	H
	Pocket wetland	H	M	H	M	H	L	H	M	L	H	M*	H	H
	Submerged gravel wetland	H	M	H	M	H	L	H	M	L	M	L	H	M
	Wetland channel	H	M	H	M	H	L	H	M	L	H	H*	H	H
Infiltration	Infiltration trench	H	H	H	M	H	H	H	H	L	L	M	L	L
	Infiltration basin	H	H	H	M	H	H	H	H	H	M	H*	L	M
	Soakaway	H	H	H	M	H	H	H	H	L	L	M	M	L
Filtration	Surface sand filter	H	H	H	M	H	L	H	M	L	M	L	H	M
	Sub surface sand filter	H	H	H	M	H	L	H	M	L	M	H	H	L
	Perimeter sand filter	H	H	H	M	H	L	H	M	L	M	L	H	L
	Bioretention/ filter strips	H	H	H	M	H	L	H	M	L	H	H	M	H
	Filter trench	H	H	H	M	H	L	H	H	L	M	M	M	L
Detention	Detention basin	M	M	L	L	L	L	H	H	H	L	H*	L	M
Open channels	Conveyance swale	H	M	M	M	H	M	H	H	H	L	M*	L	M
	Enhanced dry swale	H	H	H	M	H	M	H	H	H	L	M*	M	M
	Enhanced wet swale	H	H	M	H	H	L	H	H	H	M	M*	M	H
Source Control	Green roof	n/a	n/a	n/a	n/a	H	H	H	H	L	H	H	H	H
	Rain water harvesting	M	L	L	L	n/a	M	M	H	L	H	M*	H	L
	Permeable pavement	H	H	H	H	H	H	H	H	L	M	M	M	L

**limited data available*
H-high potential
n/a: not applicable
M-medium potential
L-low potential

A-6 Checklist for the SuDS Selection Process

Step 1: Data collation, agreement of preliminary site design criteria.

Step 2: Review development Masterplan and implement pollution prevention and optimum site layout and design, wherever possible.

Step 3: Identify feasibility of within-curtilage source control and sustainable water management options.

Step 4: Divide site into sub-catchments.

Step 5: Determine hydraulic and water quality design requirements (taking account of any benefits already accruing from Steps 2 & 3).

Step 6: Identify feasibility of potential sub-catchment/site source control options (eg infiltration trenches, infiltration swales, infiltration basins), using selection matrices.

Step 7: Identify feasibility of potential sub-catchment/site detention/treatment options (eg detention basins, ponds, wetlands, filter trenches), using selection matrices.

Step 8: Identify feasibility of potential site/regional control options (eg ponds, wetlands, basins etc), using selection matrices.

Step 9: If there is more than one component in the treatment train, are additional conveyance components required to link techniques?

Step 10: Identify feasibility of potential conveyance components (eg swales, infiltration / filter trenches, pipes, overland flood flow routes, wetland channels etc), using selection matrices.

Step 11: Does the identified SUDS management train meet all hydraulic, water quality, amenity and ecological criteria set for the site? (If not return to Step 6).

APPENDIX B - SuDS SELECTION
RATING TABLES FOR VARIOUS SuDS TECHNIQUES

Table 5.1: Decision Criteria for Selecting SUDS Techniques

Technique	Land Use Characteristics	Site Characteristics	Catchment Characteristics	Quality and Quantity Performance	Amenity and Environment	Economics and Maintenance	Total
Pervious pavements	21	14	15	12	12	8	**82**
Bioretention	23	15	18	15	16	9	**96**
Filter drains	23	18	14	13	12	8	**88**
Grassed filter strips	22	11	13	10	15	9	**80**
Swales	20	11	11	10	13	10	**75**
Infiltration devices	16	10	15	12	10	7	**70**
Infiltration basin	14	9	14	12	11	7	**67**
Extended detention basin	22	12	12	8	13	10	**77**
Wet ponds	21	14	15	13	20	9	**92**
Stormwater wetlands	21	14	16	17	22	9	**99**
On-/off line storage	14	14	13	4	9	12	**66**

Land Use Characteristics							
Technique	Urban Development	Car Parks	Roads	Housing	Local Pocket Parks	High Amenity Zoned Lands	Total Score
Pervious pavements	5	5	3	4	3	1	**21**
Bioretention	3	4	4	3	5	4	**23**
Filter drains	4	4	4	4	5	2	**23**
Grassed filter strips	2	3	5	4	5	3	**22**
Swales	3	2	5	2	4	4	**20**
Infiltration devices	2	3	2	4	3	2	**16**
Infiltration basin	2	3	2	2	3	2	**14**
Detention basin	3	3	4	4	5	3	**22**
Wet ponds	2	3	4	4	4	4	**21**
Stormwater wetlands	2	3	5	4	2	5	**21**
On-/off line storage	2	3	3	2	3	1	**14**

Site Characteristics					
Technique	Space Required	Coastal and Tidal Outfall	Low Infiltration rate	Water table > 1m	Total
Pervious pavements	5	3	3	3	**14**
Bioretention	3	4	3	5	**15**
Filter drains	5	3	5	5	**18**
Grassed filter strips	2	3	3	3	**11**
Swales	2	3	3	3	**11**
Infiltration devices	5	3	1	1	**10**
Infiltration basin	4	3	1	1	**9**
Extended detention basin	3	3	3	3	**12**
Wet ponds	2	4	4	4	**14**
Stormwater wetlands	1	5	4	4	**14**
On-/off line storage	5	3	3	3	**14**

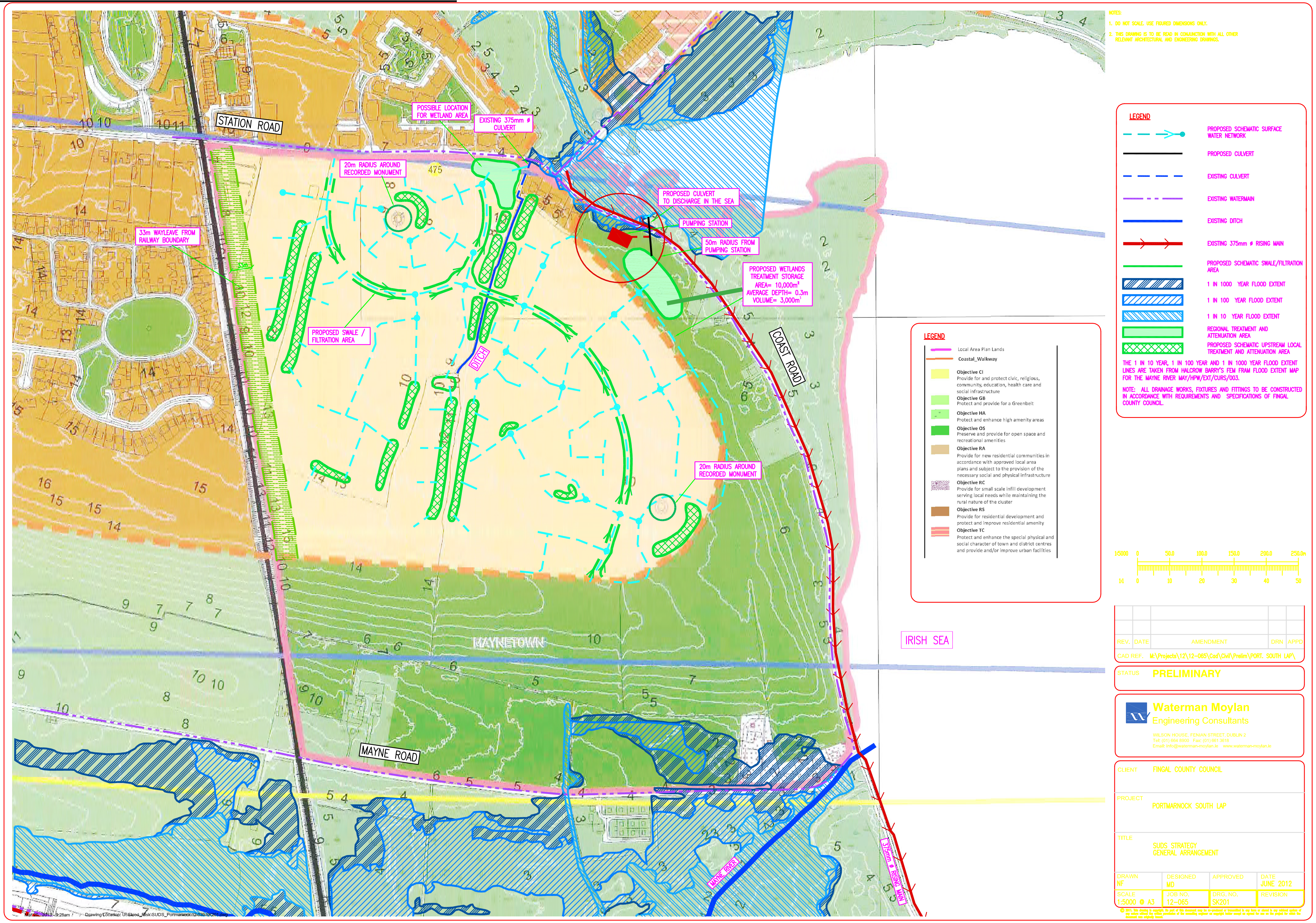
Catchment Characteristics								
Technique	**Drainage sub-catchment area**	**<2 ha**	**2-8 ha**	**> 8 ha**	**Site slope**	**1:35**	**Drain to Sensitive Area**	**Total**
Pervious pavements	Can be used for drainage of any size area provided it is split into sub-catchments	5	3	1	Ideally, level site. If sloping terracing or check dams within pavement required and care to prevent surcharging at low points	3	3	**15**
Bioretention	0.1-0.8 ha max sub-catchment size	5	4	3	Ideally no more than 6-10%, but with careful design can be used on steeply sloping sites	3	3	**18**
Filter drains	4 ha max 0.8 ha max for perimeter filter	5	2	1	Ideally no more than 6-10%	3	3	**14**
Grassed filter strips	2 ha max	5	1	1	Ideally no more than 6-10%	3	3	**13**
Swales	2 ha max	5	1	1	Ideally no more than 4-10%	2	2	**11**
Infiltration devices	2-4 ha max	5	3	1	Ideally no more than 6-10%	3	3	**15**
Infiltration basin	4 ha max	5	2	1	Ideally no more than 15%	3	3	**14**
Extended detention basin	8-10 ha min	1	2	5	Ideally no more than 15%	3	1	**12**
Wet ponds	8-10 ha min	1	2	5	Ideally no more than 15%	3	4	**15**
Stormwater wetlands	8-10 ha min (except for pocket wetlands, 2 ha min)	1	2	5	Ideally no more than 8-15%	3	5	**16**
On-/off line storage	Drainage areas of any size if good- sized flow control devices provided	3	3	3	Place storage parallel to site contours. Care to prevent surcharging in system	3	1	**13**

Quantity and Quality Performance Requirements					
	Treatment Suitability	**Hydrological**			**Total**
Technique	**Pollutant Removal**	**Water quality control**	**Groundwater recharge**	**Flow Rate Control**	
Pervious pavements	4	3	1	4	**12**
Bioretention	4	4	3	4	**15**
Filter drains	4	4	1	4	**13**
Grassed filter strips	3	3	2	2	**10**
Swales	3	3	2	2	**10**
Infiltration devices	2	2	5	3	**12**
Infiltration basin	2	2	5	3	**12**
Extended detention basin	2	2	2	2	**8**
Wet ponds	3	3	3	4	**13**
Stormwater wetlands	5	5	3	4	**17**
On-/off line storage	1	1	1	1	**4**

Amenity & Environment											
Technique	**Safety**		**Pond Premium**		**Aesthetics**		**Wildlife Habitat**		**Community Acceptance**		**Total**
Pervious pavements	Very good	5	No	1	Low	2	None	1	Moderate	3	**12**
Bioretention	Very good	4	No	1	High	4	High	4	High	3	**16**
Filter drains	Very good	5	No	1	Low	2	Very low	1	Moderate	3	**12**
Grassed filter strips	Very good	4	No	1	Low to moderate	3	Moderate	3	High	4	**15**
Swales	Good	3	No	1	Moderate	3	L	2	High	4	**13**
Infiltration devices	Very good	4	No	1	Very low	1	Very low	1	Moderate	3	**10**
Infiltration basin	Moderate - design to prevent fast inundation	3	No	1	Low	2	L	2	Moderate	3	**11**
Extended detention basin	Moderate-risk assessment required	3	No	1	Moderate	3	Moderate	3	Moderate	3	**13**
Wet ponds	Moderate-risk assessment required	3	Yes	5	High	4	High	4	High	4	**20**
Stormwater wetlands	Varies-risk assessment required	3	Yes	5	Very high	5	Very high	5	High	4	**22**
On-/off line storage	Very good	3	No	1	None	1	None	1	Moderate	3	**9**

Economics and Maintenance							
Technique	**Life span**		**Initial Cost**		**Maintenance Burden**		**Total**
Pervious pavements	Very High	2	Moderate	3	Moderate	3	**8**
Bioretention	Moderate	3	Moderate to High	3	Moderate to High	3	**9**
Filter drains	Moderate	2	Moderate to High	3	Moderate to High	3	**8**
Grassed filter strips	High	2	Low (cost of land can be high)	5	Low	2	**9**
Swales	Very High	3	Moderate	5	Moderate	2	**10**
Infiltration devices	Moderate to High	2	Moderate	3	Moderate	2	**7**
Infiltration basin	Moderate to High	2	Moderate	3	Moderate	2	**7**
Extended detention basin	High	4	Low (cost of land can be high)	2	Low	4	**10**
Wet ponds	Very High	4	Low (cost of land can be high)	1	Low	4	**9**
Stormwater wetlands	High	4	Moderate (cost of land can be high)	1	Low	4	**9**
On-/off line storage	Moderate to High	4	Moderate to High	4	Low	4	**12**

APPENDIX C - SuDS STRATEGY – GENERAL ARRANGEMENT DRAWING



APPENDIX D – SuDS FEATURES (12-065r.003)

Table of Contents

1. Introduction

1.1. Purpose of this Report

This report sets out a description of the SuDS features considered as possible options for incorporating into the detail design of the Portmarnock South LAP lands.

Also included is an assessment of the water quality improvement that may be achieved by the correct implementation of the specific features described in terms of the percentage removal of pollutants of concern.

2. Suds Features

Tree Pits and Bio-Retention Areas

Tree pits and bio-retention areas receive surface water runoff from hard standing areas including roads and car parks. The surface water drains through engineered filter material lying on top of a perforated pipe surrounded in voided stone. This perforated underdrain system discharges the treated surface water back into to the main surface water sewer system.

Tree pits and bio-retention areas can be easily incorporated into the landscaping scheme for existing and proposed developments. They can be utilized as a retrofit SuDS feature for existing developments. Existing surface water systems can be diverted through these tree pits and/or bioretention areas before discharging the treated surface water back into the existing network.

	Percentage removal of pollutants of concern					
Techniques	Total Susp. Solid	Hydro-Carbons	Total Phos-phorous	Total Nitrogen	Faecal Coli-forms[5]	Heavy Metals
Bio-retention areas	50-85	93-99	60-80	42-49	-	64-95

Figure A.1 Example of a Bioretention Area

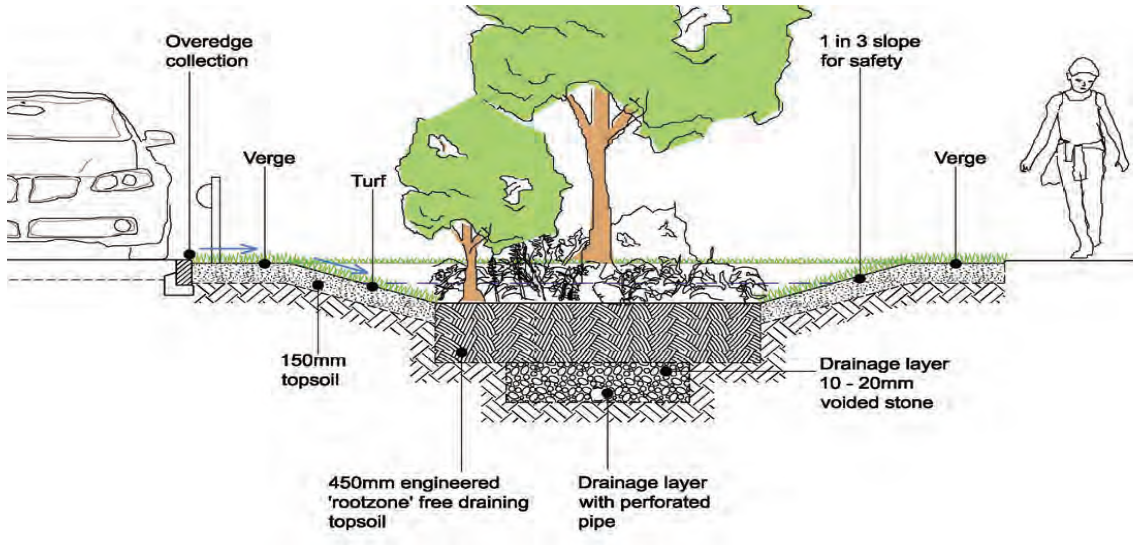


Figure A.2 Example of Tree Pits

Detention Basin

Dry (extended) detention basins/ponds are designed to detain the stormwater runoff from a design storm event and to allow sediment particles and associated pollutants to settle out. Unlike wet ponds, dry extended detention ponds do not have a permanent pool of water.

Detention basins are normally vegetated depressions that are mainly dry, except during and immediately after storm events. Detention basins can be constructed as on-line or off-line structures, and can be used as parks, playgrounds or sports fields.

The basins can be sized to accommodate the 1/30 and 1/100 storm events in accordance with criterion 2.1 and 2.2 of the GDSDS volume 2 “New Development”. A series of high level overflows can be provided of storm events in excess of the design storm.

Best practice for the geometric design of basins suggests that the bottom of the basin should be relatively flat with gradients not in excess of 1/100 towards the outlet. This is to maximize contact with vegetation and to prevent standing water in the detention area. The length to width ratio is to be between 2:1 and 5:1. Side slopes should not exceed 1:4 wherever mowing is required in order to reduce risks associated with maintenance activities.

The ecological value of the basins can be significantly improved through the provision of a micropool or wetland at the base/outlet, and for basin serving large developments and discharging directly to watercourse a sediment forebay or other upstream component will improve water quality. Extended detention ponds can be used in almost all soils and geology, with minor design adjustments for regions of karst (i.e., limestone) topography or in rapidly percolating soils such as sand. In these areas, extended detention ponds should be designed with an impermeable liner to prevent groundwater contamination or sinkhole formation.

Dry extended detention basins provide moderate pollutant removal. While they can be effective at removing some pollutants through settling, they are less effective at removing soluble pollutants due to the absence of a permanent pool. A few studies are available on the effectiveness of dry extended detention ponds. Typical removal rates, as reported by Winer, R. 2000. National Pollutant Removal Database for Stormwater Treatment Practices: 2nd Edition. Center for Watershed Protection, are:

	Percentage removal of pollutants of concern					
Techniques	Total Susp. Solid	Hydro-Carbons	Total Phos-phorous	Total Nitrogen	Faecal Coli-forms[5]	Heavy Metals
Detention Basins	29-93	-	7-32	15-47	-	29-54

Figure A.3 Example of a Detention basin

Figure A.4 Detention basin

Retention basin

Retention basins are basins or ponds that have a permanent pool of water. During a rainfall event the runoff entering the pond is detained and treated through the settlement of suspended sediments and biological uptake until it is displaced by runoff from the next storm. The pond should be designed for ease of maintenance, and should contain several zones:

1. The sediment forebay: Interception and treatment storage should ideally be accommodated up catchment. Where there are residual sediment risks, or where a sediment forebay is the only suitable management option at the site, then the pond can be split to allow coarse sediments to settle in the forebay before the runoff enters the permanent pool.

2. The permanent pool that will remain throughout the year. The permanent pool acts as the main treatment zone and helps to protect fine deposited sediments from re-suspension. The top water level for this volume should set to the invert level of the outlet structure. The use of an impermeable lining (geotextile liner or puddle clay) will help maintain the permanent water level.

3. The temporary storage volume provides flood storage and attenuation for up to the 1/100 year storm event or as required.

4. The shallow zone (aquatic bench) along the edge of the permanent pool to support wetland planting. This acts as a biological filter and provides ecology, amenity and safety benefits.

The inlet and outlet structure should be ideally placed to maximise the flow through the basin, other features such as baffles, islands, and pond shaping will also help increase the flow path hence improving the sedimentation and treatment process.

The basins can be sized to accommodate the 1/30 and 1/100 storm events in accordance with criterion 2.1 and 2.2 of the GDSDS volume 2 “New Development”. A series of high level overflows can be provided of storm events in excess of the design storm.

Retention basins provide good to moderate pollutant removal the removal of major pollutants to watercourse by this method is given in the table below:

	Percentage removal of pollutants of concern						
Techniques	Total Susp. Solid	Oils & Grease	Total Phos-phorous	Total Nitrogen	Bacteria	Heavy Metals	Nitrates
Retention Basin	29-93%	-	7-33%	15-47%	78%	29-54%	24%

Figure A.5 Retention Basin

Figure A.6 Retention Pond

Stormwater Wetland

Storm Water wetlands are specifically constructed to treat pollutants in runoff and comprise a basin with shallow water and aquatic vegetation that provides infiltration. They are one of the most effective SUDS techniques in terms of pollutant removal and offer valuable wildlife habitat as well as important aesthetic benefits to the area. Wetlands are constructed mars systems providing varying degrees of deep and shallow water. They are not normally designed to provide significant attenuation but if required to act as a water detention device the temporary storage may be provided above the level of the permanent water level.

Wetlands consist of the following elements:

- o Shallow vegetated areas of varying depths
- o Permanent pool, or micropool
- o Small depth range overlying the permanent pool, in which runoff volumes are stored
- o Sediment forebay
- o Overflow or emergency spillway

Wetlands are the most effective type of SUDS in terms of pollutant removal. As storm run-off flows through the wetland, pollutant removal is achieved through settling and biological uptake within the facility. Stormwater wetlands can provide significant reductions in sediment, nutrient, heavy metals, toxic materials, floatable materials, oxygen demanding substances, oil and grease as well as a partial reduction in bacteria and viruses.

The average removal of pollutants by stormwater wetlands is shown in Table 4.6

Table 4.6 Estimates of pollutant removal capability of Stormwater Wetlands for `assessment of SUDS management trains (CIRIA C609)

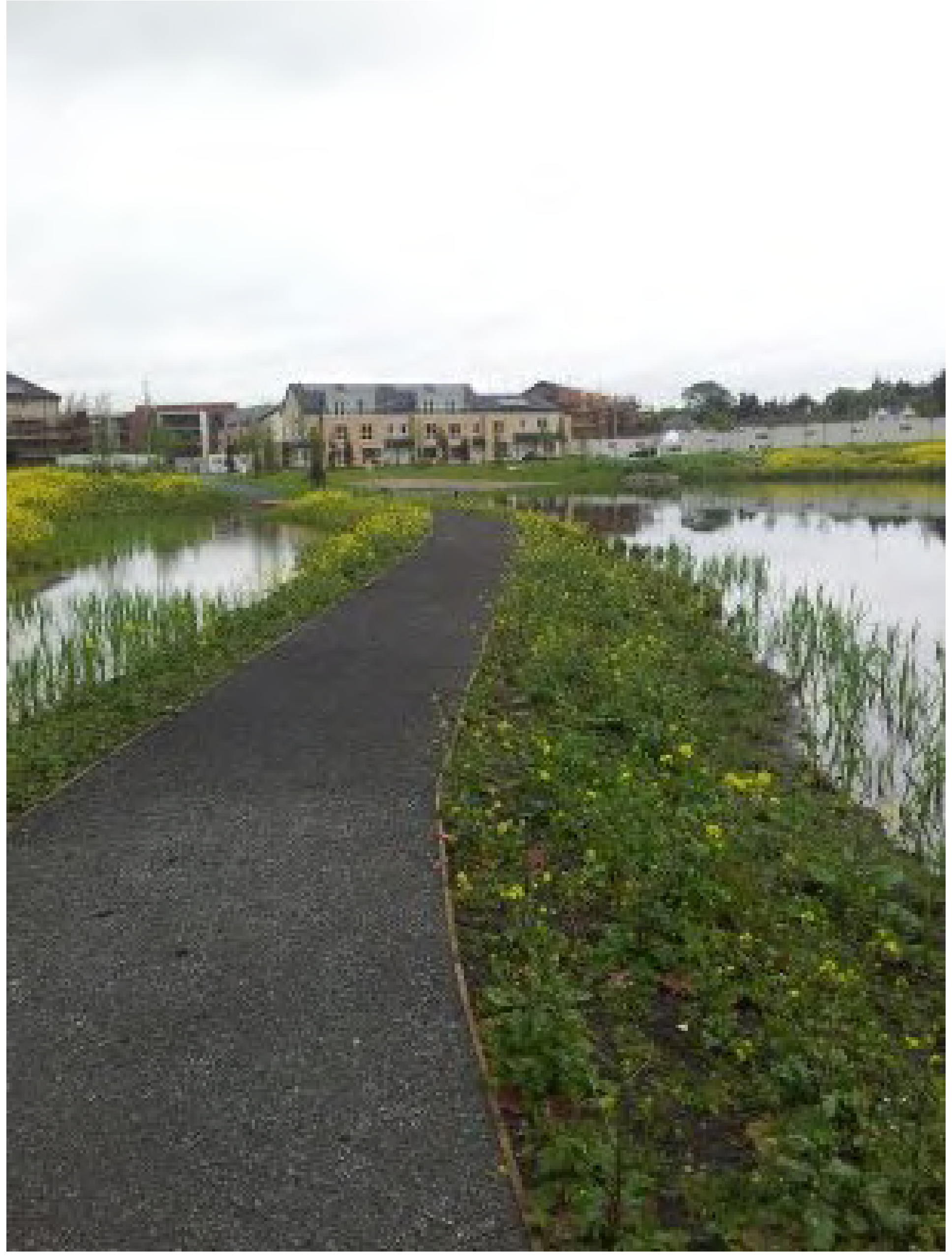
Techniques	Percentage removal of pollutants of concern[123]					
	Total Susp. Solid	Hydro-Carbons	Total Phos-phorous	Total Nitrogen	Faecal Coli-forms[5]	Heavy Metals
Storm Water Wetlands	80-90	50-80	30-40	30-60	-	50-60

1) The performance of SUDS is subject to a number of variables and the values should not be considered or used as absolute values.
2) Summary based on design values provided in Atlanta Regional Commission (200l), Barren (1998). New Jersey Department of Environmental Protection (ZOOO), Highways Agency et a1 (1998b) and reviewed against mean values quoted by United States Environmental Protection Agency (I999a to I999n) and median removal efficiency quoted by Centre for Watershed Protection (Winer. 2000).
3) Stormwater pollution concentrations are dependent on various factors and the performance of the SUDS techniques will vary. For any one storm event the observed performance may not reach the specified level (it may also be exceeded). This can be allowed for in design.
5) Removal rate for faecal coli-form is based on no resident wildfowl population in ponds and wetlands.
- Insufficient data to quote removal rate.

Figure A.7a Stormwater Wetland

Figure A.7b Stormwater Wetland

Figure A.8 Stormwater Wetland



Permeable Surfacing

Although pervious pavements are traditionally constructed using granular material for the sub-structure into which the water percolates, there are a range of high voids-ratio plastic media products also available. Voids ratios range from 30 to 95%. The water quality outflow from these pavements is generally high. It is thought that the treatment is mainly achieved by the geo-textile membrane (preferably unwoven) placed immediately below the blockwork. Therefore although geotextile might usefully be placed at the bottom of the structure for other reasons, it is unlikely to contribute to treatment of the surface water at this location. Several permeable pavements have been monitored in UK and elsewhere in the world. The volumetric reduction is largely a function of whether the pavement is lined or not, and seasonal effects. Short storms in summer often have only a nominal outflow, while long wet winter events do not achieve a significant volume reduction compared with standard drainage.

The performance of unlined pavements is a function of both the receiving soil type and construction technique, as it has been found that permeable surfaces can have their porosity significantly reduced by the construction process. It is reported that unlined pavements, even in clays, still achieve considerable reductions of runoff for ordinary events.

For systems designed to only drain by infiltration, it is important to provide a relief pipe to cope with excess runoff in case of reduced infiltration rates and / or very extended wet periods, where surcharge would be a problem. Reduction of runoff over a season of rainfall may be very great, but hydraulic design of these units should be based on their performance under extreme conditions.

Lined pavements are built where there is a concern to protect the groundwater from pollutants. For lined systems, runoff reductions are still significant although less than unlined systems. During long wet winter periods, runoff volumes might only be reduced by 30 percent in lined permeable pavements, though average annual figures have been found to be up to 55 percent. Observed runoff rates from these mechanisms, even in the wettest periods, are low, usually below 2l/s/ha, for much of the storm runoff volume. The maximum flow rates recorded are in the order of 25l/s/ha, but these may have been constrained by the outlet pipe system. The figures suggest that these units are very effective in limiting the impact of runoff on receiving streams and urban drainage systems.

	Percentage removal of pollutants of concern					
Techniques	Total Susp. Solid	Hydro-Carbons	Total Phos-phorous	Total Nitrogen	Faecal Coli-forms[5]	Heavy Metals
Pervious Pavements	60-95%	70-90%	50-80%	65-80%	-	60-95%

1) The performance of SUDS is subject to a number of variables and the values should not be considered or used as absolute values.

2) Summary based on design values provided in Atlanta Regional Commission (200I), Barren (1998). New Jersey Department of Environmental Protection (ZOOO), Highways Agency et a1 (1998b) and reviewed against mean values quoted by United States Environmental Protection Agency (I999a to I999n) and median removal efficiency quoted by Centre for Watershed Protection (Winer. 2000).

3) Stormwater pollution concentrations are dependent on various factors and the performance of the SUDS techniques will vary. For any one storm event the observed performance may not reach the specified level (it may also be exceeded). This can be allowed for in design.

4) Removal rate for faecal coli-form is based on no resident wildfowl population in ponds and wetlands.

- Insufficient data to quote removal rate.

Figures 4.2a and 4.2b below show examples of how porous asphalt and permeable paving can be used throughout the individual developments to delay/reduce storm water runoff.

Figure A.9 Permeable Paving

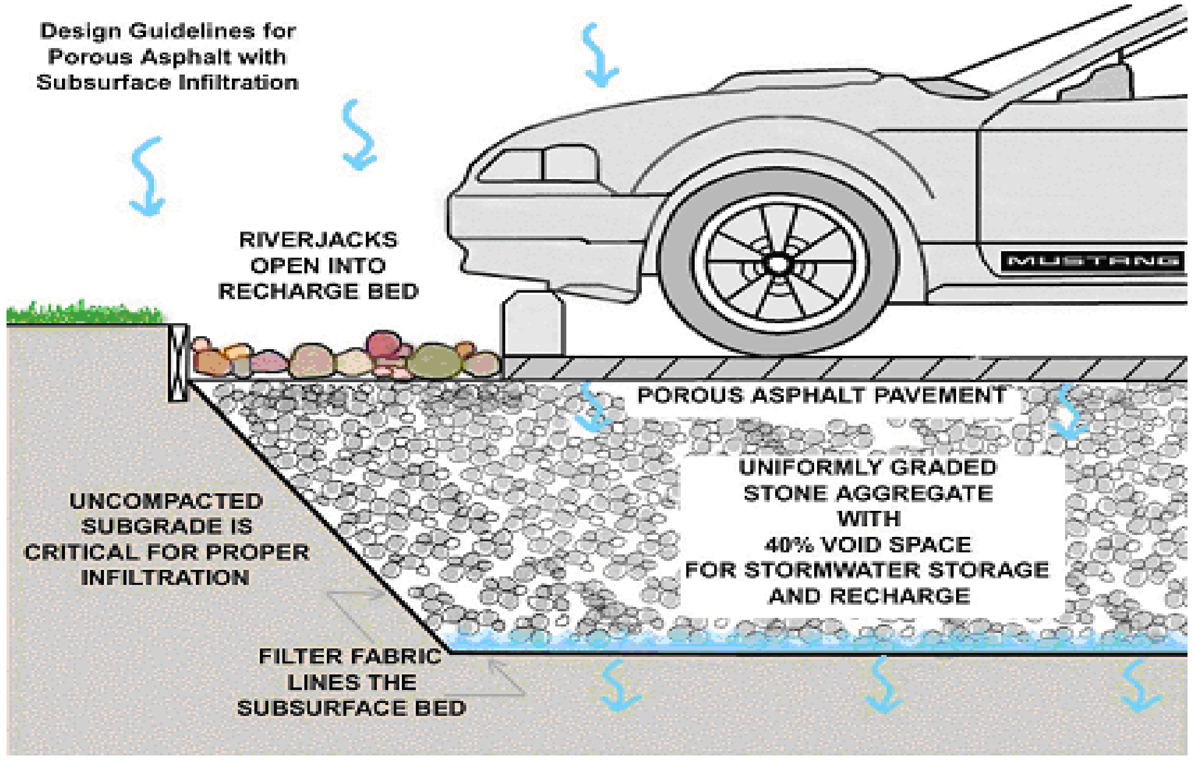
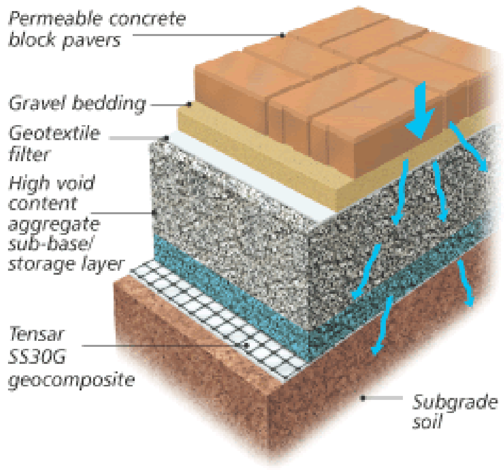


Figure A.10 Permeable Paving Dentails



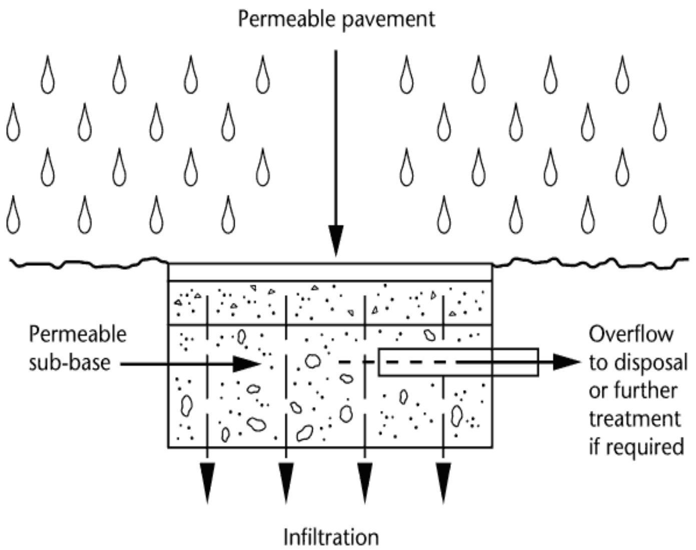


Figure A.10 Permeable Paving Dentails

Infiltration Basin

These are designed depressions for the storage of stromwater runoff for infiltration into the subgrade. This facilitates the recharge of groundwater resources and replenishment of surface water base flows. Infiltration Basins also have the additional benefit of significantly removing pollutants and suspended solids through the process of filtration through the underlying unsaturated soils.

Infiltration basins are ideally used for small storm events and should be used to treat surface water runoff, in an offline function, from smaller catchments. Pretreatment prior to infiltration is required to ensure long-term performance of the basin.

Infiltration basins require a large accessible area which is relatively flat and highly pervious. The side slopes are to be no steeper than a grade of 1:4 to facilitate maintenance, and grass cutting. The basin floor should level, and design should account for seasonally high water tables, and provide a minimum of 1.0m of unsaturated soils, beneath the base of the device, for infiltration purposes.

Figure A.11 Infiltration Basin

Infiltration Trench

Infiltration trenches are shallow excavations filled with gravel, rubble, stones or other void forming media creating a temporary subsurface storage for storm water runoff.

Infiltration trenches can be used to capture point flow, from down pipe gully connection etc, or sheet flow from a paved surface. The surface water runoff is treated through infiltration through the soil. This reduces the runoff volumes, recharges groundwater and retards flows to the watercourse.

Trenches are best located adjacent to impermeable surface such as car parks or access roads, and can be incorporated into landscaping and public open spaces, and through good design minimize land take requirements. Infiltration trenches can be located underneath open spaces enabling a dual use of lands.

Infiltration trenches are best used on sites without significant slopes. The longitudinal slopes should generally not exceed 2%, as treatment of surface water flows is ideally suited to the lower flow velocities in the trench. The water table seasonal highs should be at least 1.0m below the invert of the trench to provide for an adequate infiltration rate and treatment in the unsaturated soils.

There are three elements to the design of filter trenches that require consideration:

1. Design of filter material to percolate water.
2. Design of filter material to store water
3. Design of pipe system to convey water

Fill materials are normally graded stone/rock 40-60mm in diameter, as it is important that the voids ratio is sufficiently high to allow for adequate percolation.

Geotextiles should be used to prevent soil piping but should have a greater permeability that the subsoil's it drains to.

Figure A.12 Infiltration Trench

Swales

Swales are linear vegetated drainage strips typically provided along roads in grass verges and in public open spaces to delay/reduce runoff in times of extreme storm events.

The objective is to use the swale as a retention basin and for runoff treatment, with flows passing to a perforated drainage pipe below the swale. This enables the swale to be designed as a balancing system with a controlled outflow based on the pipe size serving the system of swales. The great advantage of this system is that there is considerably less risk of erosion from flows passing along the swale as they will tend to be short individual lengths. The physical problems related to pipe connections, which are needed to pass under roads and driveways crossing the swale, are also avoided. Inflow / outflow design should be based on infiltration techniques and the hydraulic constraint of the receiving pipe. In addition the under-drain is likely to have a continuous low flow during wet winter periods and some account of this should be made in checking on the possible range of the system performance. Design therefore requires careful application to make the most of this drainage system.

Figure A.13 Schematic of Swale area in public open space along/between roads

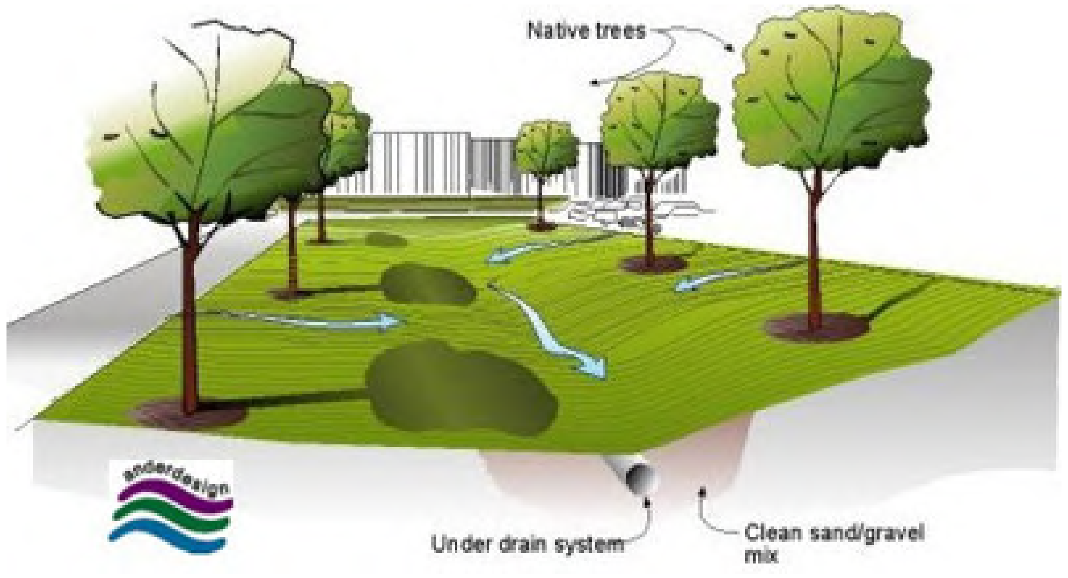


Figure A.14 Swale

Figure A.15 Swale – Flow restriction through pipe diameter

Soakaways for Hard Areas

Soakaways can be used for roof water only, as the high sediment loads from road runoff usually cause blockage problems within 20 years.

All soakaway structures should be evaluated for extreme event exceedence and provided with overflow pipework where a certain level of service cannot be assured and there is a risk of flooding as a result. Consideration of topography is important to ensure overland flows are directed away from properties. Infiltration trenches are an alternative to soakaways. They tend to be more effective in many instances as they allow much greater efficiencies to be achieved, due to the units having greater surface area per unit volume. Also as the bottom of the trench tends to be nearer the surface than the base of a soakaway, this reduces the risk of direct interaction between the infiltration unit and the groundwater table.

The use of Infiltration trenches in private properties to serve roofs is at some risk due to landscaping and gardening activities. They should be located at sufficient depth to ensure that they are unlikely to be damaged. They should not be located on common boundaries as the construction of fences and hedges will damage the drainage system. The location of filter drains should theoretically be constrained in the same way as soakaways, and should be at least 5m from the property in compliance with Building Regulations. However as they are not deep, it is suggested that the minimum distance should be at least three times the depth of the trench, assuming adjacent buildings have appropriate foundations.

In the UK, where pervious pavements have been used as infiltration units, these have been located as close as 1m from the property where the soil is highly permeable. A 10 year event is commonly used for design of property infiltration systems. However this might be increased significantly if they are seen as one of the mechanisms for meeting the requirement for "long term" storage.

These mechanisms should individually serve only one or very few properties. This is needed to avoid flow taking place along a trench to a low point and focusing all the potential flooding in one garden / location.

Soakaways should be provided on each individual property taking runoff from the dwelling roof. A series of soakaways shall be linked together by means of overflow pipes should the inflow exceed the infiltration rate, with this overflow discharging into the main storm water system.

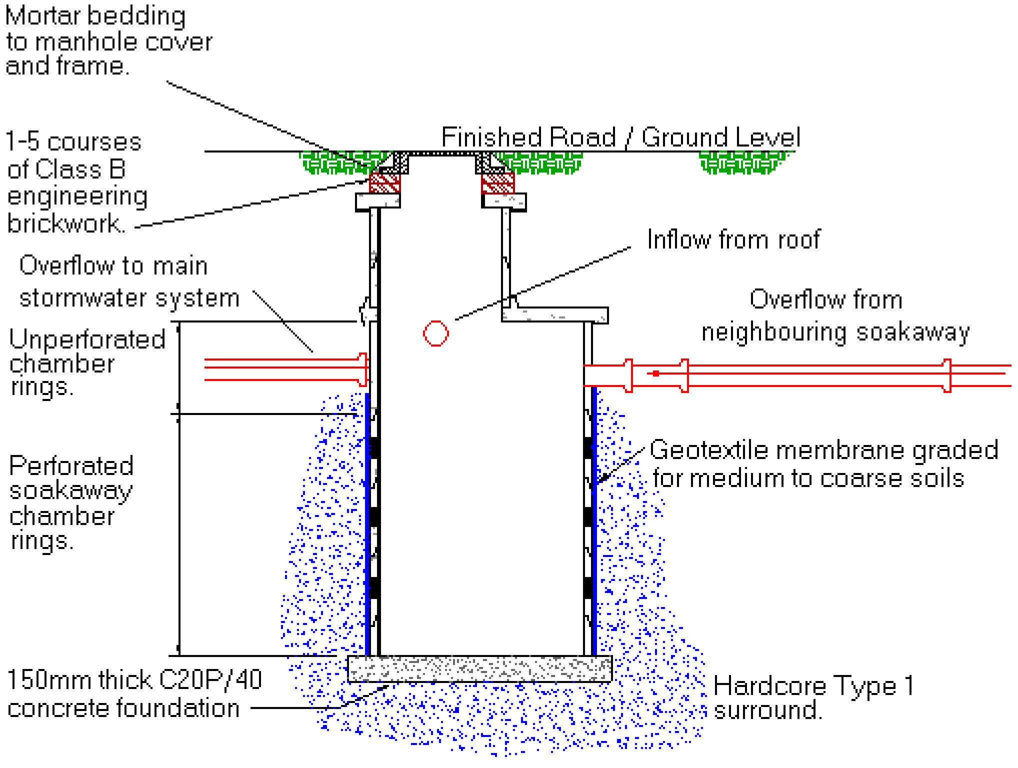


Figure A.16 Soakaway cross-section

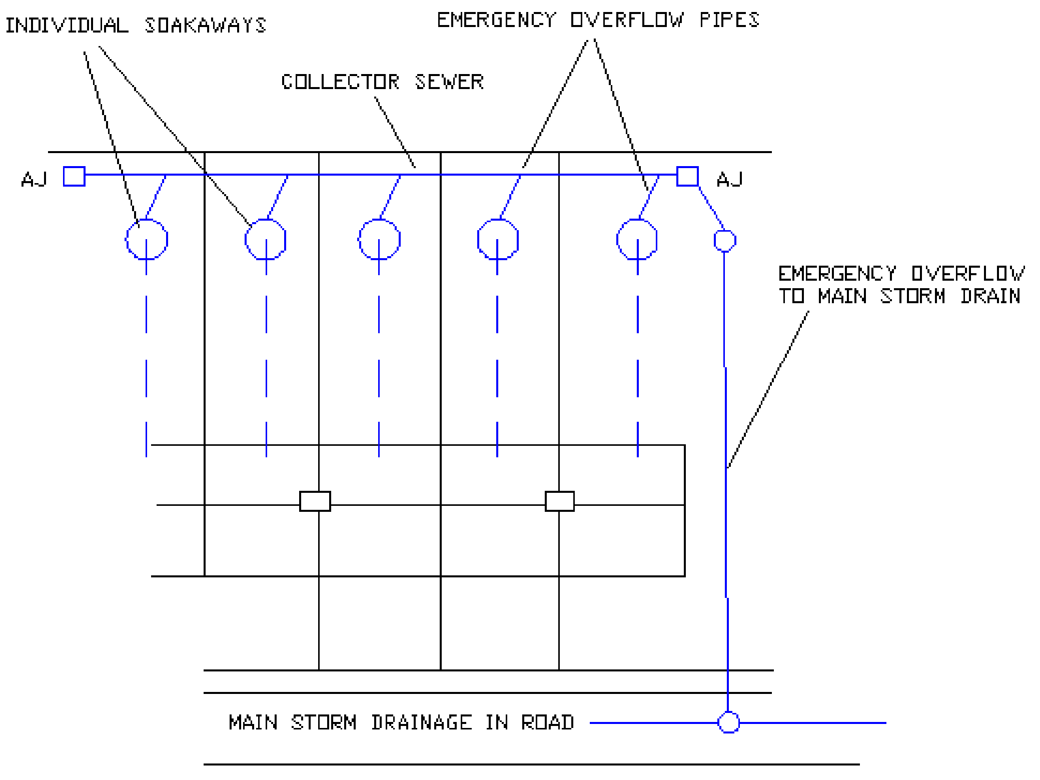


Figure A.17 Plan view - Soakaways in series.

Rainwater Harvesting

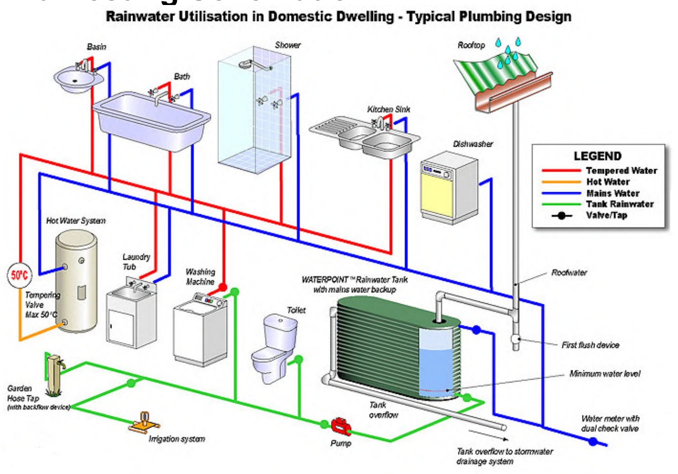
Rainwater harvesting is the collection and storage of rain from roofs for future use. The water is generally stored in rainwater tanks and piped back into residential industrial or commercial development to be used for general domestic use, irrigation, and landscaping uses. The rainwater storage tank shall have an overflow pipe to the main sewer or soakaway/infiltration system.

These systems are installed to be used in normal everyday use and for the mains to takeover/ provide supply automatically in times of dry weather. It has the following advantages;

- Softer water for washing - less corrosion on machinery and less detergents used
- Ideal for garden watering as the water is soft and contains no chlorine
- Reduces burdens on sewer systems.
- Rainwater is ideal in industry and commercial buildings, especially for low grade process water
- Reduces future investment in increasingly expensive and lengthy projects for new water developments
- Reduces pressure on water resources
- Suitable for washing vehicles
- Reduction on expensive treatment of mains water using power and chemicals
- Contributes to reduced flooding problems
- Reduces demand for mains water.

Sizing of the rainwater harvesting systems should be based on average rainfall data for the area and expected demand for harvested water in order to provide an efficient sizing for the storage tank.

Figure A.18 Rainwater Harvesting Schematic



Green Roofs

Green roofs are a multi-layered system that covers the roof of a building or podium structure with vegetation over a drainage layer.

Green roof systems are used to reduce the volume and rate of runoff from development roofs, and hence reduce the amount of hardstanding resulting from a development.

There are three main classifications of greenroofs:

Extensive green roofs - These cover the entire roof area with low growing low maintenance plants. This system comprises of 25mm-125mm of hardy drought tolerant mosses, succulents, herbs and grasses.

Intensive green roofs – These are landscaped environments of high amenity which include trees grasses shrubs and planters. Intensive green roofs can be used for the storage of stormwater.

Simple intensive green roofs – These are vegetated with lawns or ground covering plants. These roof systems require regular maintenance.

Figure A.19 Extensive Greenroof system